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1) Abstract

This deliverable reports the results of the characterization of traditional process for making salted/smoked Kitoza in 3 production sites (2 dedicated to beef Kitoza production and 1 dedicated to pork Kitoza) and the evolution of biochemical characteristics (water, salt, Aw, pH, titrable acidity, D and L-lactic acid, phenol and B(a)P contents) during the processes.

This kinetic study allowed to define better the unit operations involved in the process and their impact on product quality. Salted/smoked Kitoza making process allows decrease of meat water content particularly during smoking. Salt content increases due to dry salting and due to its concentration because of water loss during smoking. Thus, Aw decreases during dry salting. The smoking step for which different resources were used (wood, charcoal, wood shavings) allows the combination of unit operations of drying, cooking and smoking.

The product reached phenol content that varies from 0.19 ± 0.05 to 2.59 ± 0.9 mg/100g depending of the producer. But smoking led to levels of B(a)P that were sometimes higher than French regulation (5µg/kg; 2µg/kg from September 2014) notably for the most smoked/dried samples smoked with wood.

2) Introduction

Kitoza is a traditional Malagasy meat product made from strips of beef but also pork meat. Long time considered as a royal delicacy, it still has an important role in the daily meal of Malagasy people. It is presented as 20-50cm x 2-3cm strips, salted, sun-dried and/or smoked either above the fire in the kitchen until their consumption, or in smoking units. It is no more just prepared by housewives but presently produced at higher modern commercial levels (butchers and a few small firms).

In WP1, the analysis of 60 end-products (30 salted/smoked, 30 salted/dried) showed that salted/smoked Kitoza contained approximately 50 g/100g of water, 3 g/100g of salt and showed a water activity of 0.93 on average. They are thus classified mainly in food with high moisture content while the most dried products are in the zone of intermediate humidity food. Smoking of the product however led to benzo(a)pyrene content (indicator of carcinogenic compound contamination of cooked and smoked meat products) above the norm of 5 ppb in 10 samples. Moreover, if the final pH values (of the order of 5.8) indicated that Kitoza is not a fermented food, 9 samples of which 3 smoked Kitoza had some D-lactic acid content as described in dry-sausages, a well known fermented meat product.

The present deliverable reports the results of the the kinetic characterization of smoked Kitoza process. 3 production sites had been visited, 2 dedicated to the beef Kitoza manufacture and 1 dedicated to pork Kitoza production. The objectives were to determine and better understand the different unit operations involved in salted/smoked Kitoza processing and to study the evolution of physico-chemical characteristics of the product during the process. Finally, the purpose was to identify critical points which will be resolve by the work of reengineering (tasks 3.2 and 3.3).

3) Materials and methods

a) Area of study

The characterization of traditional processings of Kitoza was conducted in Antananarivo.

b) Number of producers and production/producer followed

The study was conducted with 3 producers (2 producing beef Kitoza and 1 pork Kitoza).
Preliminary visit was organised in order to inform the producer about the project objectives. For each producer, we had 3 observation and interview visits, each lasting about 3h. The first one was for steps description (including weighing meats and ingredients) and step operator and site responsible interviews. Samples were collected during the second visit. A second production was followed in a third visit during which samples were collected in the same time meat and ingredients were weighed.
In the following, for each producer, results of the first production are highlighted in grey and those of the second production in yellow.

c) Characterization of operational parameters

Synthetic transformation diagrams, step diagrams, step quantitative elements, step qualitative description and interviews were established according to D3.1.2.1.

d) Sampling

Sampling was undertaken at various production steps (raw material, after cutting into strips, ingredients adding and mixture and smoking) in order to determine microbiological and physico-chemical characteristics of the product (Table 1). For each step, 3*600g of strips (600g = 1-2 strips) or of meat pieces for raw material were collected and put in 3 plastic bags. Samples were carried in an icebox (about 4°C) to the lab (which takes about 1h for producers 1 and 2 and 2h for producer 3). Each sample was cut in cubes ($1cm^3$) that were mixed.

e) Analyses

For each sample, 200g of cubes was used for immediate microbiological analysis for D3.1.1.1. The rest of the sample was frozen at -20°C for other analysis described in Table 1 and performed according to SOPs specific to group 2.

Table 1: Sampling steps and physico-chemical parameters analysed

Analysis	Sampling steps			
	Raw material	Cutting into strips	Ingredients adding and mixture	Smoking
Lipids	X	not required	not required	X
Proteins	X	not required	not required	X
Water	X	X	X	X
NaCl	not required	not required	X	X
Aw	X	X	X	X
pH	X	X	X	X
Titrable acidity	X	X	X	X
D and L lactic acids	X	X	X	X
Glucose	X	X	X	X
Phenols	X	not required	not required	X
HAP	not required	not required	not required	X
TBARS	X	X	X	X

4) Results for site type n°1 salted/smoked beef Kitoza

a) General presentation

The producer was selected following the work undertaken within the WP1 framework (sample 12). The producer expressed his willingness to participate in the project. He already undertook improvements in his workshop.

The workshop which is also a butchers'shop, is located in Antananarivo in the Ivandry area, in the northern part of town. The producer is a specialist in smoked meat products and other delicatessen products from beef, pork and chicken. There are 10 workers in the workshop.

For each production (2 to 6 times a week), 5 to 10kg of Kitoza (beef or pork) is produced according to the day and the sale season.

Kitoza sale price is 25 000 Ariary/kg.

b) Synthetic traditional transformation diagram

The process applied by this producer is a traditional process with 5 steps (ST) as presented above.

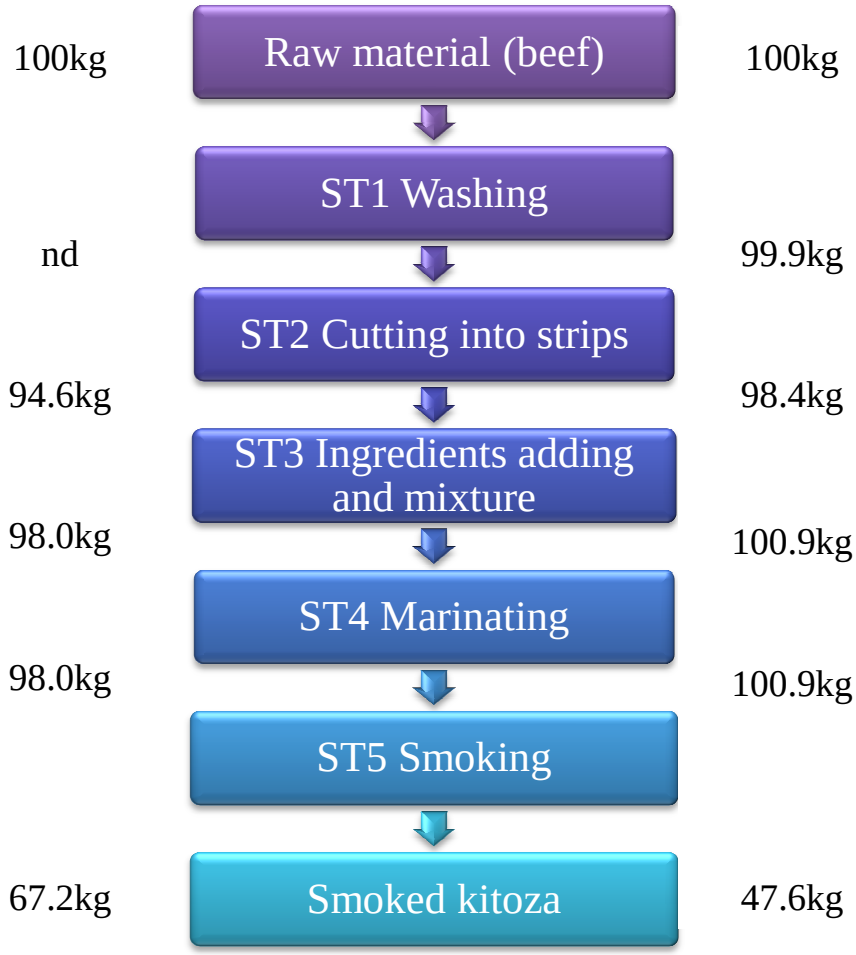


Figure 1: Site type n°1 transformation diagram and mass balance basis 100kg

c) Transformation site general scheme

Figure 2 shows the plan of the transformation site and the equipments and rooms used for the different steps of Kitoza production. All rooms are at ambient temperature.

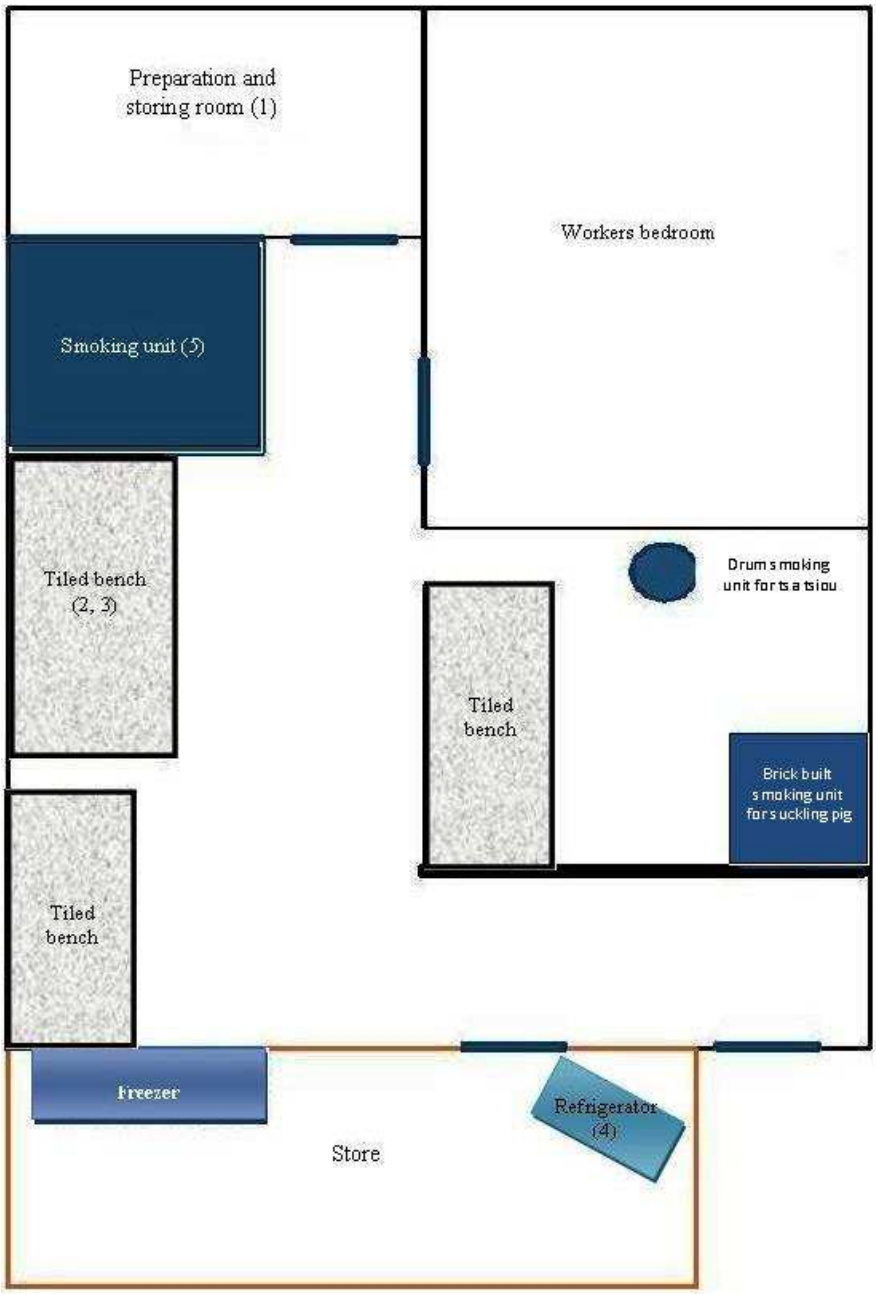


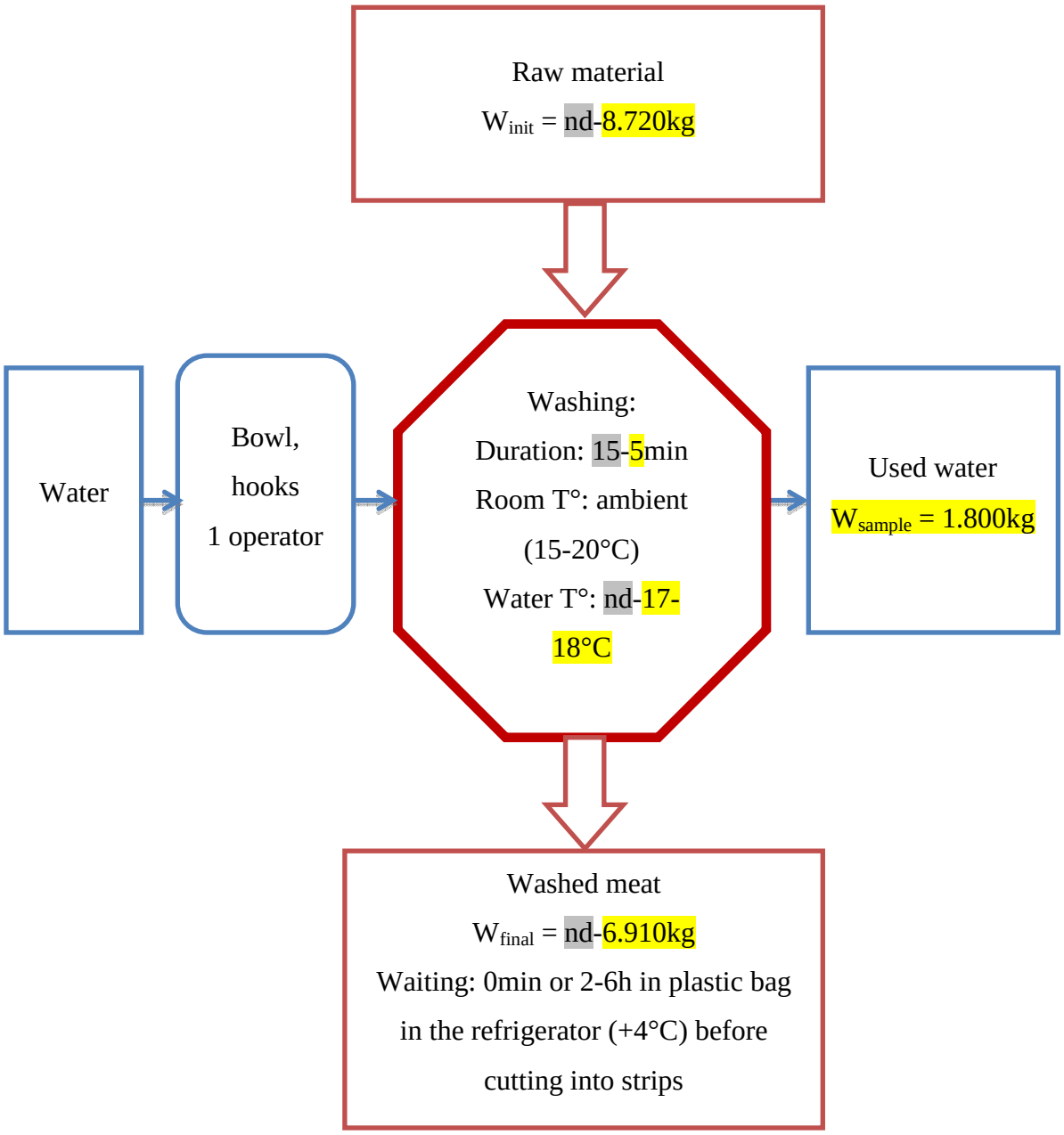
Figure 2: Site type n°1 transformation site

(1 - Washing; 2 - Cutting into strips; 3 - Ingredients adding and mixture; 4 - Marinating; 5 - Smoking)

Refrigerator temperature was read on the fridge and room temperature was measured with a thermometer placed on one of the benches. Meat was weighed with the store balance.

d) Documents of step 1: washing

Step diagram



Step quantitative elements

Washing is done in a room at ambient temperature. As washing was realized before the visit, the ambient temperature was not measured but is generally between 15-20°C in Antananarivo at this season at this moment of the day.

Water temperature was measured with a datalogger.

Step qualitative description

Meat part destinated for Kitoza is called « thin slice » (« tranche fine » in french), non fat meat of the tenderness of filet (Figure 6a)). The site responsible purchased raw material at 6 o'clock in the morning the day of production at the slaughtering site. Meat is transported up to the site of transformation at ambient temperature in a plastic bag.

Meat requires washing due to the lack of cleanliness in slaughtering areas and transport conditions. Meat is washed once receptioned. This step lasts about 5-15min. As running water is not available, water is kept at ambient temperature in two 200L barrels filled twice daily at the nearest public fountain. Before washing the meat, the operator washes his hands with soap. The bench and the bowl are cleaned by scrubbing with soap and then rinsed before receiving the meat. Meat is soaked in a large bowl full of water and rinsed until rinsing water is clear. Washed meat is then hung on a hook on an iron bar near the benches in order to let remaining water drip.

It is then submitted to the following step. Otherwise, and for the two productions we followed, it is kept in the refrigerator at 4°C in a plastic bag during 2-6h.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *No.*

Q3: What are the available energy sources?

Q4: What are the most laborious, dangerous movements?

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how?

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from? *The bowl is an imported product.*

Q2: Purchased? Where? *At the local market.*

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work? *Once it is broken, it cannot be used any more.*

Q8: What do you do with the tool once it has been no more useful? *Bowls are thrown away.*

c) Product quality

Q1: What was the previous step?

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *The rinsing water is clear.*

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products? *Water is thrown away.*

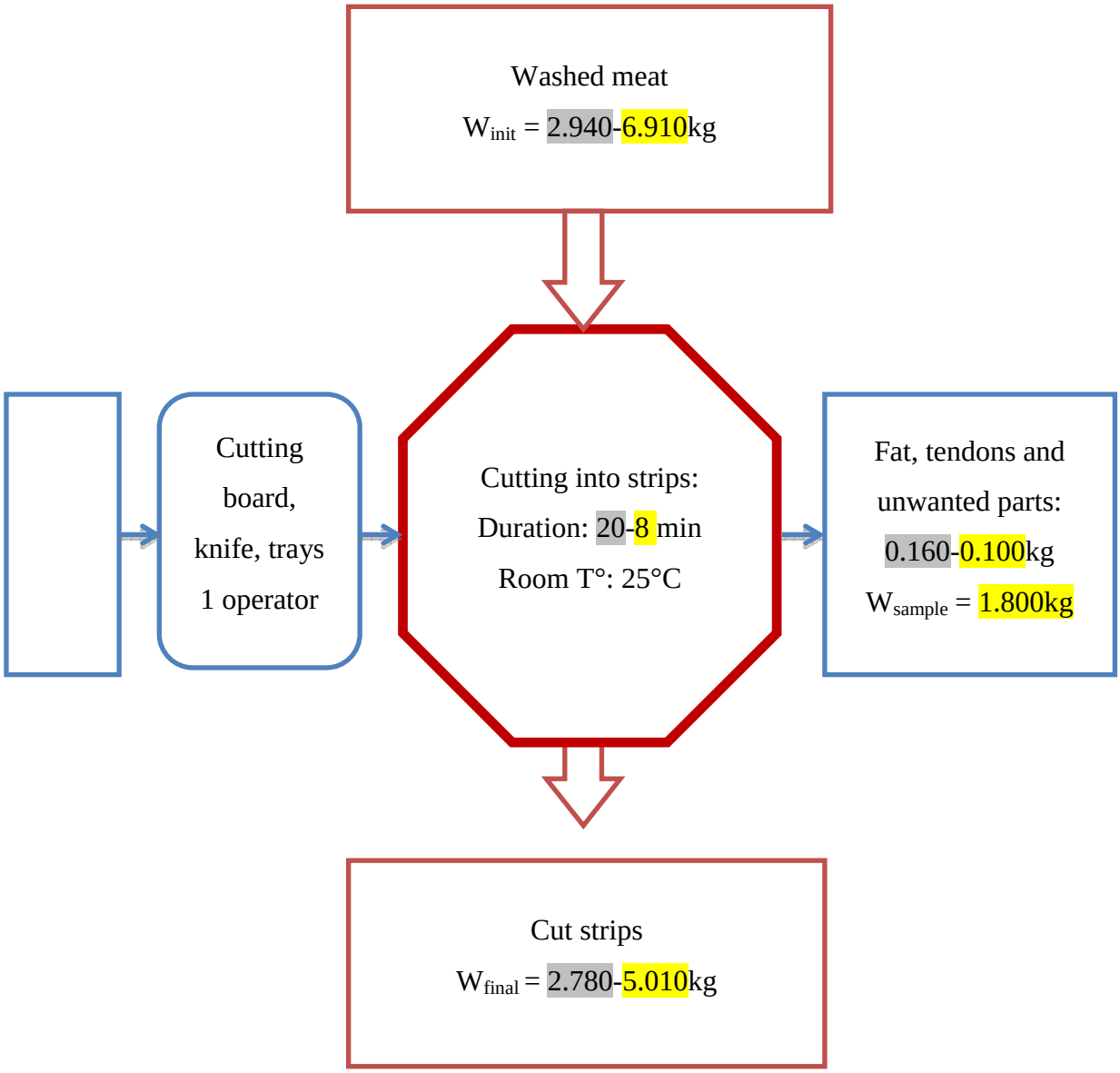
Q11: What is the next step? *Cutting into strips.*

Q12: Once the product ready, is it immediately treated at the next step? *Not always.*

Q13: Otherwise in what conditions should it wait for the next step (duration, container, temperature)? *2 to 6h in the refrigerator (+4°C).*

e) Documents of step 2: cutting into strips

Step diagram



Step quantitative elements

Step qualitative description

Before cutting the meat, the operator washes his hands with soap. The bench and all tools used for cutting strips, adding ingredients and marinating are cleaned by scrubbing with soap and then rinsed before receiving the meat.

Once everything is ready, the meat is layed on the cutting board. Fat, tendons and unwanted parts are cut away (Figure 6b)). Rejected parts following cutting into strips represent about 1-5% of initial meat mass. They are not discarded but used to make sausages or similar products.

The meat is first cut in thin slices perpendicularily to the fibers (Figure 6c)), then in 30cm long x 2-3cm thick strips (Figure 6d)). Strips can be of various length depending on the initial piece used.

This step lasts 8-20min.

It is then submitted to the following step.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged?

Q3: What are the available enenergy sources?

Q4: What are the most laborious, dangerous movements? *We are used to the work and therefore no task is laborious. However the strips cutting procedure can be dangerous for someone not used to do the work.*

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how? *Yes, it can, by using a more sharpened knife.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify? *Yes, the tool (the knife) correctly works. I am not aware of a more adapted tool.*

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from? *The knife is made in Ambatolampy where all butcher knives are made.The cutting board is locally made. Trays are imported.*

Q2: Purchased? Where? *A salesman delivers the knife to us. The remaining other tools are bought at the local market and other shops.*

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work? *Once broken, it cannot be used any more.*

Q8: What do you do with the tool once it has been no more useful? *Trays are thrown away.*

c) Product quality

Q1: What was the previous step? *Washing.*

Q2: Is the product immediately treated? *Not always.*

Q3: If not, in what conditions should it wait (duration, container, temperature)? *2 to 6h in the refrigerator (+4°C).*

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *All the meat is cut into strips.*

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products? *Fat and unwanted parts (tendons) are used to make sausages.*

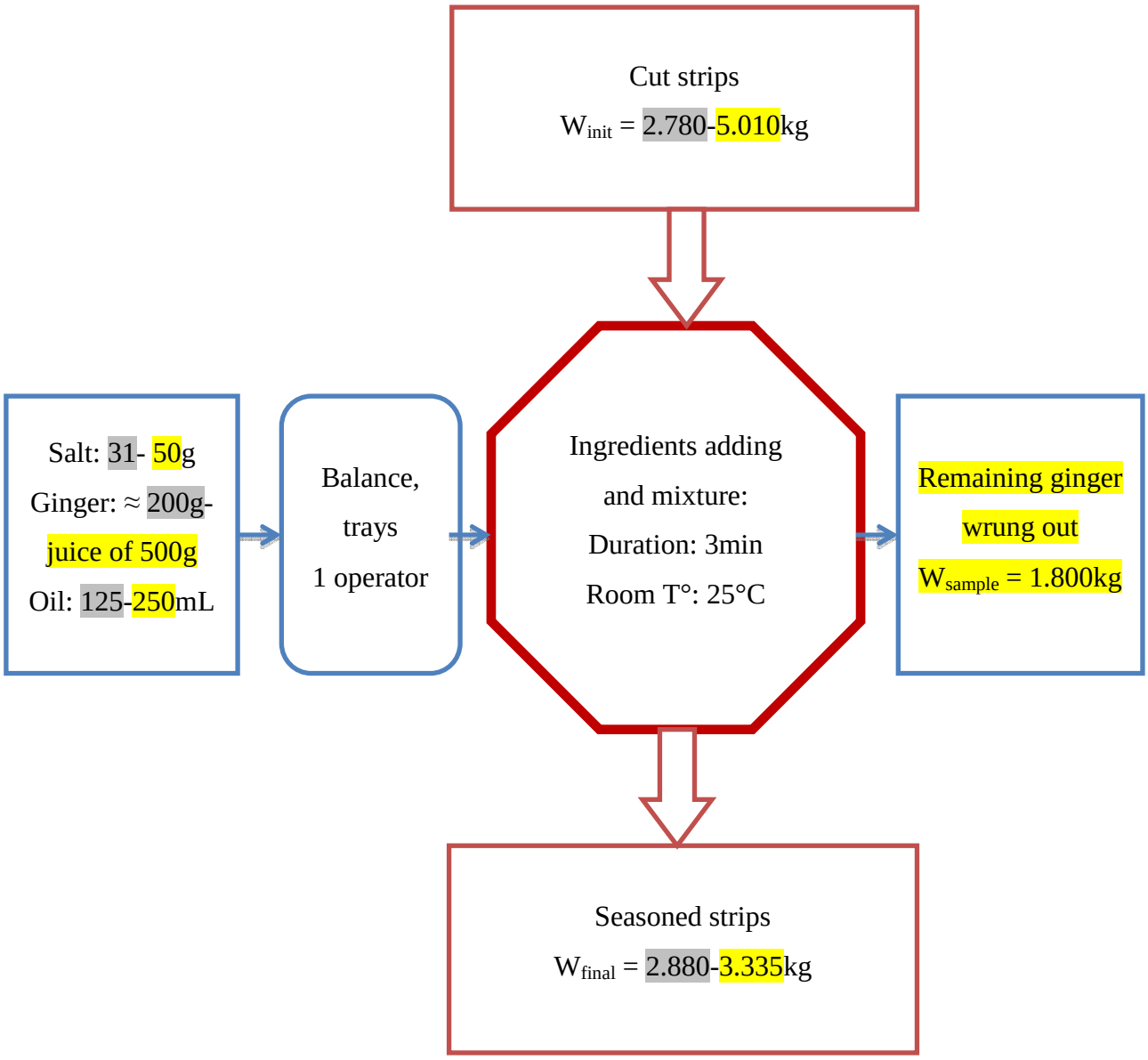
Q11: What is the next step? *Ingredients adding and mixing.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

f) Documents of step 3: ingredients adding and mixture

Step diagram



Step quantitative elements

Oil, salt and ginger are used as ingredients. The operator weighs salt at a rate of around 10 g/kg of fresh meat. Usually a handful of ginger is used. The amount of oil added is not measured by the operator. We estimated the weight of ginger and the volume of oil added knowing the volume of the bottle.

Step qualitative description

Ingredients are bought at the wholesaler's.

During the weighing step (1min), cut strips are left on a tray in the open air. Ingredients are added and mixed with the meat by hand for about 2min (Figure 6e)). The operator told us that oil is added to insure tenderness to the meat since it is not very fat.

Operator step interview

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *No.*

Q3: What are the available enenergy sources?

Q4: What are the most laborious, dangerous movements?

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how?

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from? *Trays are imported products.*

Q2: Purchased? Where? *They are purchased at the market and other shops.*

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful? *Trays are thrown away.*

c) Product quality

Q1: What was the previous step? *Cutting into strips.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached?

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products? *Remaining ginger wrung out is thrown away.*

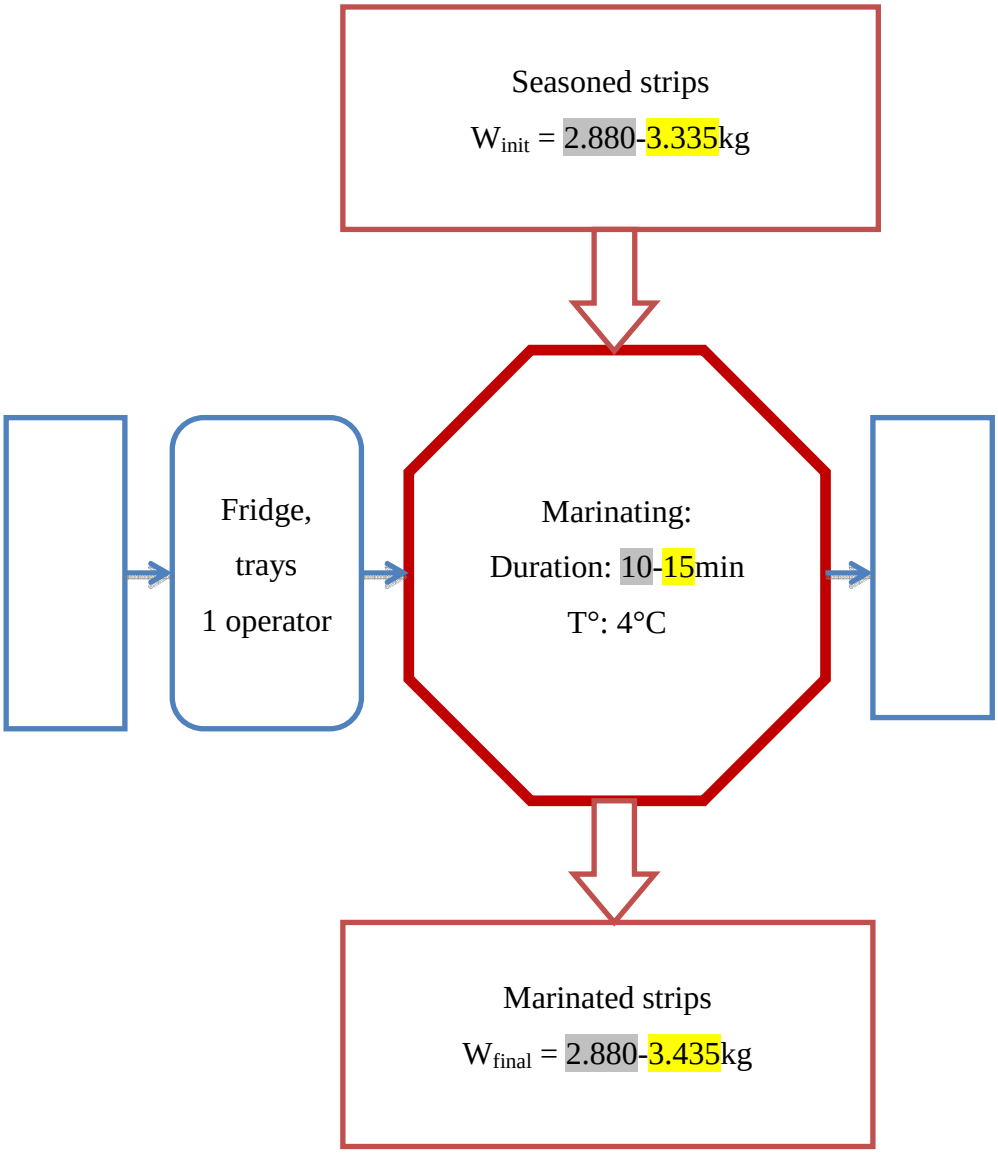
Q11: What is the next step? *Marinating.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

g) Documents of step 4: marinating

Step diagram



Step quantitative elements

For the second production, the increase of meat weights recorded is probably an error. Also, final weight was was considered to be 3.335kg for the calculations of the matter balance.

Step qualitative description

In order to let the ingredients deeply impregnate the meat, seasoned strips are kept in the refrigerator (+4°C) for 10min. This cooling process also protects the product from exposure to microorganisms. Meanwhile, the fire is let on for the next smoking step.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *No.*

Q3: What are the available enenergy sources? *Electricity.*

Q4: What are the most laborious, dangerous movements? *None, the reason for this is that we are familiar with the operation.*

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how? *Marinating could be shortened since the meat is already tender enough.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from?

Q2: Purchased? Where? *The refrigerator was purchased in a special shop in town.*

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful? *Unusable refrigerator is sold to a recycler of this type of machine.*

c) Product quality

Q1: What was the previous step? *Salting.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *The step is timed.*

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products?

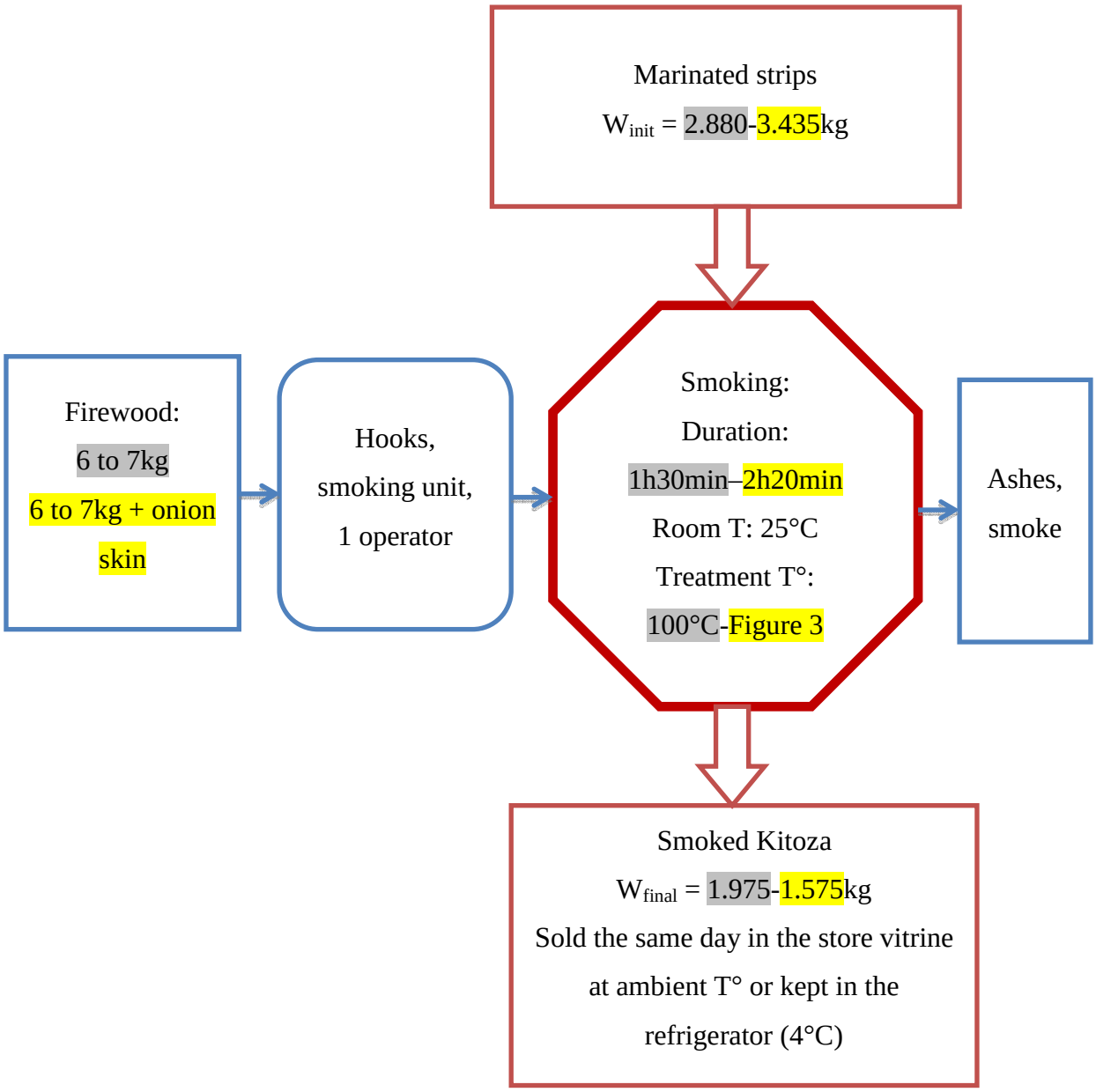
Q11: What is the next step? *Smoking.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

h) Documents of step 5: smoking

Step diagram



Step quantitative elements

For the first production, treatment temperature was measured with a thermometer (0-100°C) which was placed in the smoking unit next to the hooks. It indicates 100°C after 30min and until the end.

For the second production, treatment temperature was measured with a datalogger. Three probes were used. One was put on the surface of one strip (in 1mm of thickness). The second was put in the middle of a strip, and the third one was placed 10cm below the strips to measure the temperature in the smoking unit. The evolution of temperatures during the smoking step is shown Figure 3.

6 wooden heaps (1kg each) were used and the operator started to use the 7th.

For the second production initial weight was considered to be 3.335kg for the calculations of the matter balance due to the error made in weights measurements during marination step.

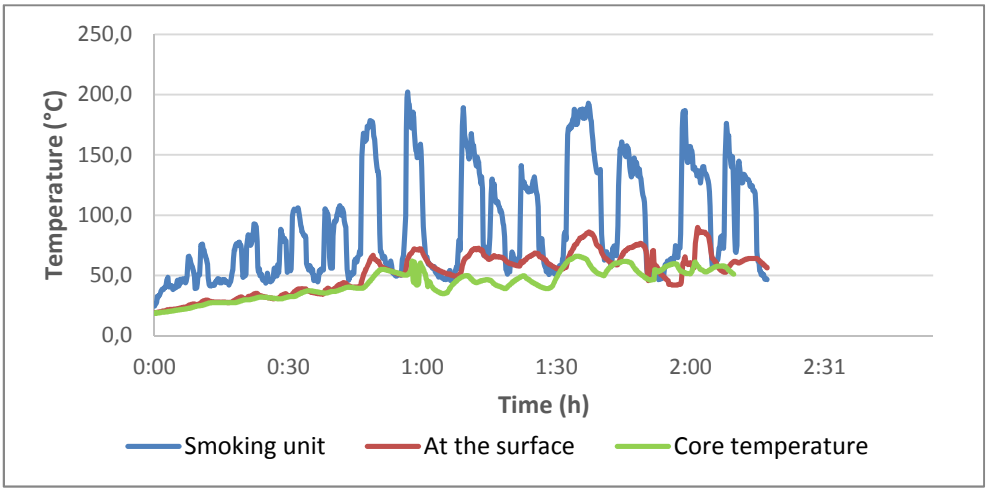


Figure 3: Evolution of temperature during smoking of site type n°1

Step qualitative description

Once the fire is ready (Figure 6f)), the operator washes his hands with soap. Strips are hung with hooks, short strips with big hooks and long strips with short ones before being introduced in the smoking unit (Figure 6g)). This can last 3min during which meat is at ambiant temperature (25°C).

Hooks are layered on bars put 10cm away from each other in the smoking unit. Strips are placed about 1m20 abouve the fire. All inlets are closed (Figure 6h)). Eucalyptus is best to be

used since it is without cracks and lasts longer. Fire needs to be well monitored. Big flames have to be avoided as well as too much smoke. In this case, the inlets have to be opened for a while and the operator removes wood from the smoking unit.

The operation lasts 1h30min. The operator may add firewood in case of need. About 6 to 7 kg of firewood is needed.

After 1h30, the operator takes visually the decision to stop the smoking step. The Kitoza is taken out of the smoking unit with a kraft paper to keep it clean (Figure 6i)).

This step is particularly difficult during the rainy season since the wood may not be well dried and setting the fire thus become awkward. It happened for the second production and that's why duration of smoking was longer. In this case the operator let the inlets opened and the appropriate temperature is more difficult to reach that can lead to a non sufficiently cooked meat. This also leads to a waste of time, firewood and especially a less good quality of the Kitoza which smells too much smoke and is difficult to sell. Smoke can also fill the whole room. This doesn't disturb the workers but in the long term, may cause chronic intoxication and diseases for them.

The smoking unit plan is shown Figures 4 and 5:

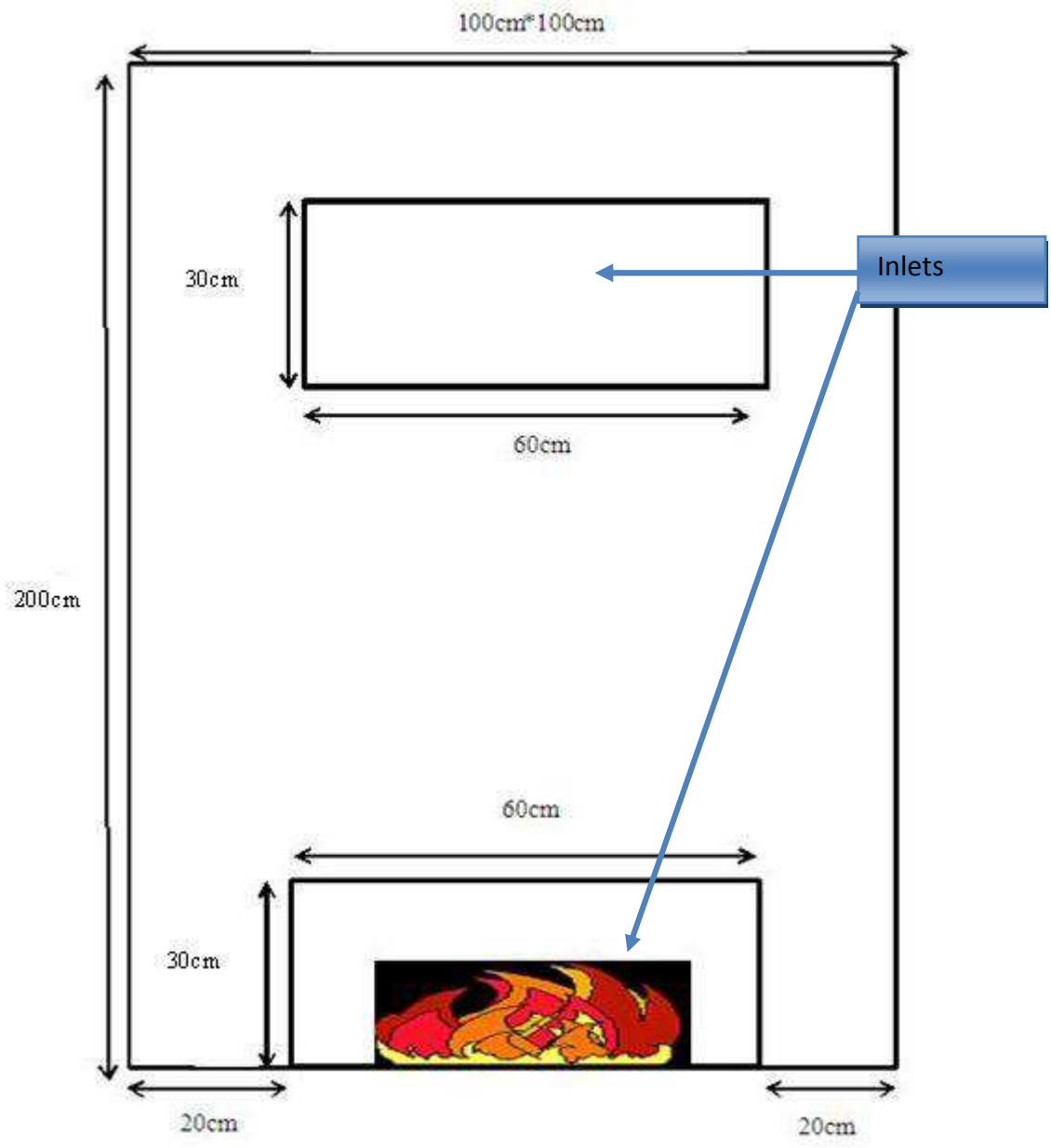


Figure 4: Site type n°1 smoking unit face view

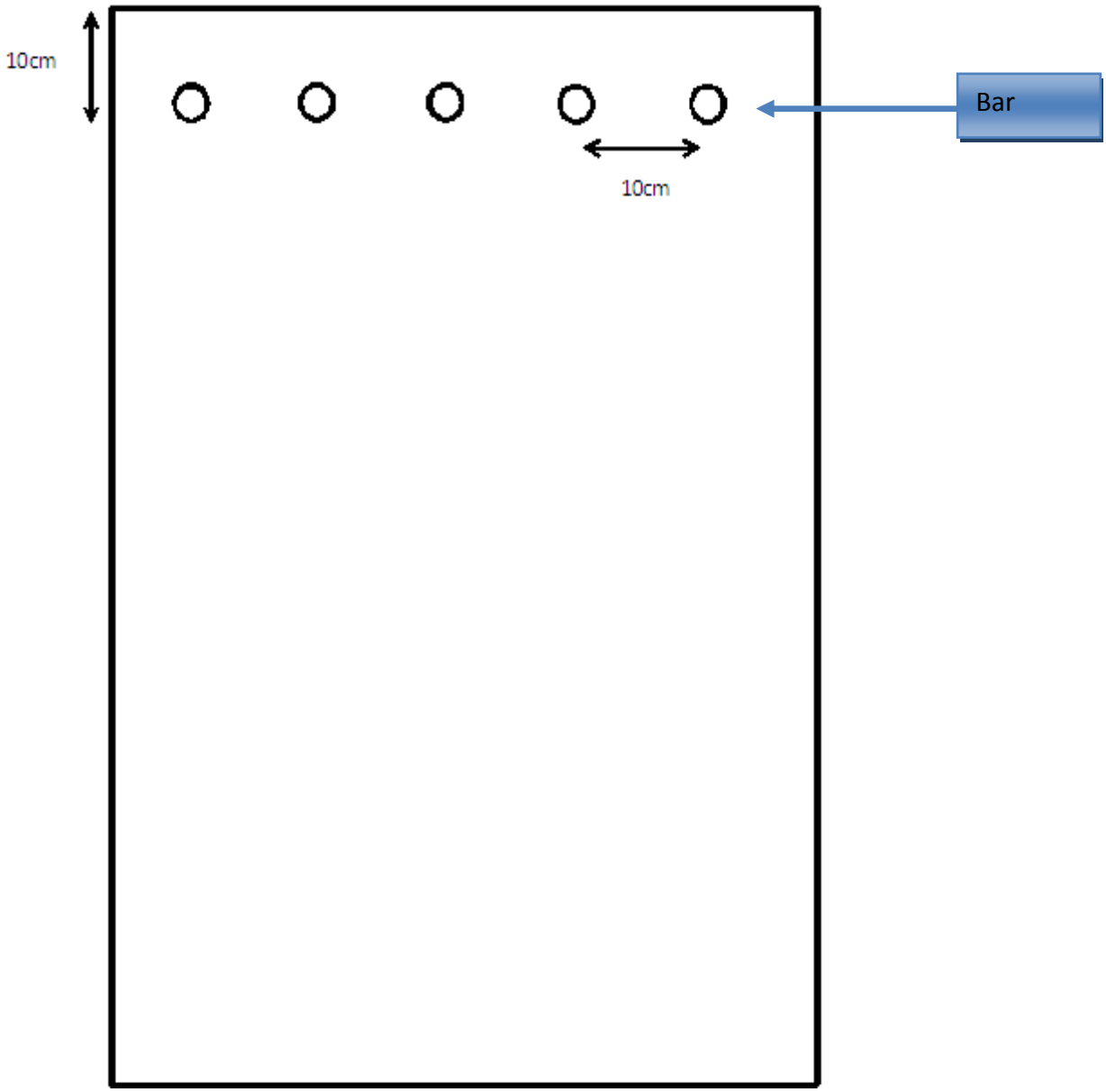


Figure 5: Site type n°1 smoking unit cross view

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *No.*

Q3: What are the available energy sources? *Eucalyptus firewood.*

Q4: What are the most laborious, dangerous movements? *None, since we are used to the task.*

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how? *No.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from?

Q2: Purchased? Where?

Q3: Locally made? *Only the smoking unit is locally made.*

Q4: Easy to make? (Can spareparts be found?) *Yes.*

Q5: Does the machine need to be dismantable in small parts? *No, smoking unit is not dismantable.*

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful? *It never happened to the smoking unit.*

c) Product quality

Q1: What was the previous step? Marinating.

Q2: Is the product immediately treated? Yes.

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *The step is carefully observed from time to time. Moreover the exact duration of the process is already known.*

Q9: Can the step « fail »? Please be precise. *Yes, it can, when there is too much flame. This burns the Kitoza.*

Q10: What do you do with discarded products? *When the Kitoza is burnt, it is served with rice for the workers.*

Q11: What is the next step? *Sale.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

i) Photos

a) Meat piece of “thin slice”

b)Cleaning the meat

c) Cutting into slices

d) Cutting into strips

e) Mixing meat and ingredients

f) Fire setting

g) Meats strips in the smoking unit

h) smoking unit inlets

i) Kitoza while took out

Figure 6: Photos of processing steps of Kitoza in site type n°1

j) Cost table

In order to assess the workshop expenses, a cost table (Table 2) was established.

Table 2: Site type n°1 cost table

Type	Unit	Price
Electricity	KWh (kilowatt-hour)	248 Ariary/kWh 1st trunk 334 Ariary/kWh 2nd trunk
Water	barrel 200L	500 Ar/barrel
Firewood	kg	120 Ariary/kg
Workers	Daily paiement	4000 Ariary daily
Raw material	kg	6800 Ariary/kg
Other ingredients	Powdered salt: 200g Ginger: g Oil: L	Salt: 150 Ariary/package Ginger: 1000 Ariary/kg Oil: 5000 Ariary/L

Local currency: Ariary; conversion rate: 1 € = 3000 Ariary

k) Evolution of physico-chemical characteristics during the process

Samples physico-chemical characteristics are presented in Table 3.

Table 3: Site type n°1 analyses results

Parameter and unit of measurement	Raw material	Cutting into strips	Ingredients adding and mixture	Smoking
Lipid (g/100g)	0.9±0.2[a] 2.2±0.8[a]	nd	nd	3.4±0.7[b] 7.0±0.5[b]
Lipid (g/100g dwb)	4.2±0.8[a] 9.0±3.4[a]	nd	nd	9.2±1.7[b] 15.7±1.7[a]
Protein (g/100g)	23.5±1.6[a] nd	nd	nd	33.1±2.0[b] nd
Protein (g/100g dwb)	103.3±6.9[a] nd	nd	nd	90.4±3.4[b] nd

Water (g/100g)	77.2±0.1[a] 76.1±0.6[a]	75.3±0.9[b] 74.8±0.4[a]	74.5±0.4[b] 74.3±0.7[a]	63.4±1.4[c] 55.6±1.8[b]
Water (g/100g dwb)	339.4±1.3[a] 319.0±11.0[a]	305.6±14.4[b] 296.7±5.8[b]	292.7±6.7[b] 289.6±11.4[b]	173.3±11.0[c] 125.7±9.1[c]
Salt (g/100g)	nd	nd	1.37±0.27[a] 0.99±0.04[a]	1.68±0.22[a] 1.61±0.14[b]
Salt (g/100g dwb)	nd	nd	5.36±1.00[a] 3.85±0.23[a]	4.59±0.44[a] 3.62±0.32[a]
Aw	0.997±0.004[a] 0.990±0.001[a]	0.995±0,009[a] 0.989±0.001[a]	0.985±0.013[a,b] 0.984±0.003[b]	0.958±0.029[b] 0.968±0.003[c]
pH	5.82±0.03[a] 5.59±0.16[a,b]	5.42±0.09[b] 5.40±0.01[c]	5.60±0.11[c] 5.54±0.06[a,c]	5.85±0.03[a] 5.72±0.02[b]
Titrable acidity (meq/100g)	10.2±0.7[a] 9.6±0.9[a]	10.2±2.2[a] 9.8±1.3[a]	11.1±2.6[a] 10.4±0.2[a]	18.7±3.0[b] 14.5±1.4[b]
Titrable acidity (meq/100g dwb)	45.0 ±3.1[a] 40.3 ±3.6[a]	41.5±9.1[a] 38.9 ±5.3[a,b]	43.5±9.6[a] 40.6 ±1.0[a]	51.1±9.1[a] 32.8 ±3.1[b]
D-Lactic acid (g/100g)	<0.014[a] <0.014[a]	0.017±0.004[a *] <0.014[a]	<0.014[a] <0.014[a]	0.020±0.008[a] <0.014[a]
D-Lactic acid (g/100g dwb)	<0.062±0.000[a] <0.059±0.001[a]	0.065±0.015[a *] <0.056±0.001[b]	<0.055±0.001[a] <0.054±0.001[b]	0.054±0.023[a] <0.032±0.002[c]
L-Lactic acid (g/100g)	0.67±0.02[a] 0.64±0.08[a]	0.82±0.03[b] 0.74±0.02[a]	0.74±0.03[c] 0.74±0.08[a]	0.91±0.04[d] 1.29±0.10[b]
L-Lactic acid (g/100g dwb)	2.94±0.09[a] 2.67±0.29[a]	3.33±0.14[b] 2.94±0.13[a]	2.89±0.16[a] 2.88±0.34[a]	2.49±0.07[c] 2.91±0.32[a]
Glucose (g/100g)	0.022±0.002[a] 0.153±0.054[a]	0.155±0.030[b,c] 0.222±0.028[a,b]	0.131±0.030[b] 0.188±0.006[b]	0.200±0.031[c] 0.209±0.021[a,b]
Glucose (g/100g dwb)	0.022±0.000[a] 0.635±0.207[a,b]	0.020±0.001[a] 0.880±0.117[c]	0.043±0.010[b] 0.733±0.035[b,c]	0.016±0.003[a] 0.473±0.063[a]
Phenols (mg/100g)	0.00±0.01[a] nd	nd	nd	2.59±0.39[b] 2.10±0.25
Phenols (mg/100g dwb)	0.02±0.03[a] nd	nd	nd	7.06±0.98[b] 4.74±0.60

PAH (µg/kg)	B(a)A	nd	nd	nd	28.70±2.50 13.19±2.08
	B(b)F	nd	nd	nd	11.93±0.78 5.66±1.04
	B(a)P	nd	nd	nd	11.23±1.63 6.92±1.18
PAH (µg/kg dwb)	B(a)A	nd	nd	nd	85.94±17.20 29.70±3.89
	B(b)F	nd	nd	nd	32.30±7.10 12.79±2.47
	B(a)P	nd	nd	nd	34.54±6.01 15.58±2.28
TBARS (mg MDA/kg)		0.03±0.00^{a} 0.34±0.06^{a}	0.03±0.00^{a} 0.26±0.01^{a}	0.14±0.14^{a,b} 0.30±0.03^{a}	0.30±0.18^{b} 0.85±0.30^{b}
TBARS (mg MDA/kg dwb)		0.13±0.02^{a,b} 1.44±0.25^{a,b}	0.12±0.01^{b} 1.01±0.03^{a}	0.55±0.56^{a,b} 1.17±0.13^{a}	0.82±0.47^{b} 1.89±0.59^{b}

dwb: dry weight basis; n=3 samples; the intervals shown are standard deviation; within one line, different letters show significant difference at 95% between steps of process; nd: not determined; *1 sample/3 was lower than the detection threshold and mean was calculated taking for this sample a value equal to the detection threshold (0.014 g/100g)

Lipid content (dwb) increased due to oil addition during the ingredients adding and mixture step.

The smoking step allows the combination of unit operations of drying (as shown by the decrease in water content), cooking (as internal temperature reached about 60°C) and smoking. Phenol content of Kitoza was around 2-2.5 mg/100g. But smoking leds to levels of B(a)P higher than French regulation (5µg/kg ; 2µg/kg in September 2014). Meat salt content increase due to dry-salting unit operation and due to its concentration because of water loss during smoking. Thus Aw decreases during the process. There was no sign of lactic acid fermentation (as D lactic acid content and titrable acidity dwb did not increase and glucose content and pH did not decrease).

TBARS content in raw material remains low during all the process.

There were differences between the 2 productions notably considering the water loss that was higher for the second production probably due to the longer smoking step. However the aw was not lower due to the lower salting. Even if the salt quantity used was higher for the second production, perhaps the juice of ginger used leds to drain some of the salt. We can also note that even if the smoking was shorter for the first production there was higher HAP deposits on meats strips.

l) Site reponsible interview

Questions addressed to site responsible (if it makes sense):

a) Raw material and intrants

Q1: Where does the raw material come from? *From Anosizato slaughterhouse.*

Q2: How long before the transformation is it purchased? *All products are purchased at 6'clock in the morning. It takes thus for Kitoza 2 to 6 hours before transformation.*

Q3: How is it stocked? *For a transformation of the same day, the meat is kept in the refrigerator (+4°C). The other ingredients are left at room temperature on shelves.*

Q4: How is quality judged? *A good meat is bright red.*

Q5: Could it be not fit for transformation? *No.*

Q6: Is the raw material quality important for the quality of final product? *Yes. This is the reason why meat for Kitoza preparation is well selected: only « thin slice ».*

Q7: Could there be any shortage? *No, since the shop's need is known.*

Q8: Can the purchasing cost be a hindrance? *No, but the sale price may go up.*

Q9: Would it be possible to work with other kind of meat? *May be, probably with mutton or chicken.*

Q10: Could there be an intrant shortage? *No.*

Q11: Could intrants purchasing cost be a hindrance to the activity? *No.*

Q12: Is it possible to work with other intrants? *No.*

b) Product quality and sale

Q13: Do you have « competitors »? *Yes, we have.*

Q14: If yes, how is your product in comparison to theirs?

Q15: Better or lesser quality (give precision)? *No idea.*

Q16: More or less expensive? *At about the same price.*

Q17: What about quality warranty? Do you carry out analysis? *The colour and taste reflect the cooked product quality.*

Q18: Are there quality requirements to respect? What are they? *The workshop floor and bench have to be tiled and include a refrigerator.*

Q19: Are end products stocked? *Kitoza is generally sold out the same day. However if there are any left-overs, they are kept in the refrigerator (+4°C).*

Q20: In what conditions. How much is left?

Q21: How far do you sell the products? *Only in Antananarivo. However, we envisage to sell in the provinces.*

Q22: Why don't you export? to the neighboring countries? To Europe?

c) Workshop, manpower and tool conditions

Q23: Is the workshop legally recognized? How? Is it important / mandatory? *Yes, it is mandatory to pay tax (sale permit).*

Q24: Do you receive inspection visits? By whom and how often? *Yes, a medical doctor from the Ministry of health comes. It happens twice a year. He controls the butcher's notebook and the workshop. In addition, another medical doctor mades a visit every morning to check the meat and verify the veterinary's stamp from the slaughtering center.*

Q25: Are there any standardised rules for the work and the working areas? *The working areas must be tiled.*

Q26: Is the staff competent? Well trained? *Yes, all workers are trained by the manager.*

Q27: Do any steps require a special knowledge and initiatives from the operator? *Yes. It is for this reason that the workers are required to have college education. They can take some initiatives but may have to ask for permission.*

Q28: How long does an employee stay at the workshop? *The longest stay is up to 5 years. The workers are fired only after major fault.*

Q29: Why don't you extend the enterprise? *It is not possible for the moment since there is a national project to enlarge the road and the workshop might be torn down. Moreover the*

improvement we undertook is not yet paid back by the landlord. We thus have to wait for the end of the 5 years lease before extension. We would like though to have another sale place.
Q30: Do you intend to renovate the material? Which one and why? *We would like to have a big presentation glass shelf to protect the sausages from dust.*
Q31: Could yougive us the approximate prices of process equipment? *Knife: 2500 Ariary per unit. Cutting board: 60000 Ariary per unit. Tray: 2400 Ariary per unit. Balance: 90000 Ariary per unit. Refrigerator/Freezer: 1000000 Ariary per unit. Presentation glass shelf: 700000 Ariary per unit.*
Q32: Why don't you make it? *We are renewing the equipment little by little.*
Q33: Do you have problems with the neighborhood (odors, noise, smoke, other, ...)? *Not yet so far. Yet we are staying cautious. The city garbage service passes every morning.*
Q34: If so, what are the solutions provided?

The interviews of the site responsible and the step operators show that there is not much difficulties in their work; however, they need training in order to correctly fullfill their tasks. Kitoza production is only restricted by the cost of raw material and intrants. The sale price however has not increased.
All products used to make Kitoza were well verified in order to insure a good quality. The site responsible also carries out an investment in the improvement of the site. He made an effort to get better equipments as well as looking for more sale sites.

5) Results of site type n°2 salted/smoked beef Kitoza

a) General presentation

Kitoza in this site is produced according to the chinese manner. What make this producer different is that he performs smoking in two steps.

This producer was willing to work within the WP1 project (sample 5). Moreover, his product was well appreciated during the sensorial test of the WP5.

The workshop also serves as a sale area and as a snack and is located in the city center, namely Behoririka area. The staff consists of seven workers working in the kitchen. One operator makes the Kitoza.

Kitoza production (only with beef) varies from 2 to 5 kg, 1 to 3 times a week.

Sale price of Kitoza is 25 000 Ariary/kg.

b) Synthetic traditionnal diagram

The process applied by this producer is a traditional process with 6 steps (ST) as presented Figure 7.

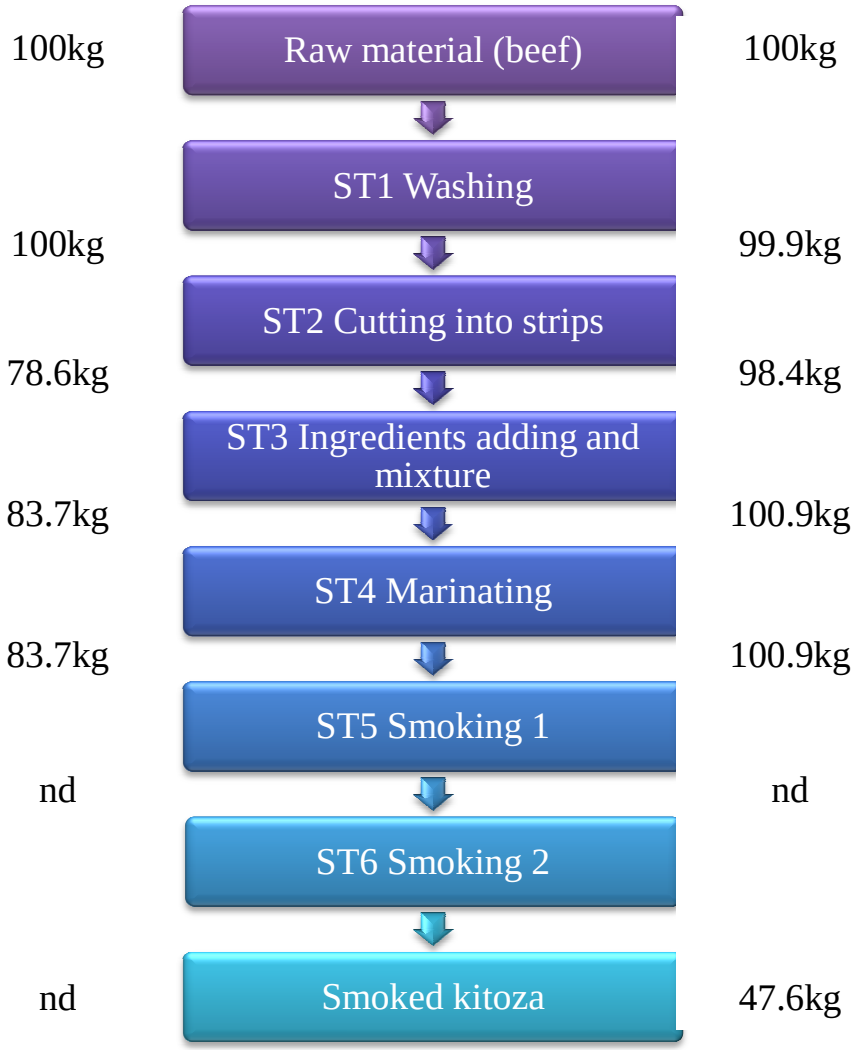


Figure 7: Site type n°2 transformation diagram and mass balance basis 100kg

For this producer, sampling was realized on raw material, after cutting into strips, ingredients adding and mixture, smoking 1 and smoking 2.

c) Transformation site general scheme

Figure 8 shows the plan of the transformation site and the equipments and rooms used for the different steps of Kitoza production. All rooms are at ambient temperature.

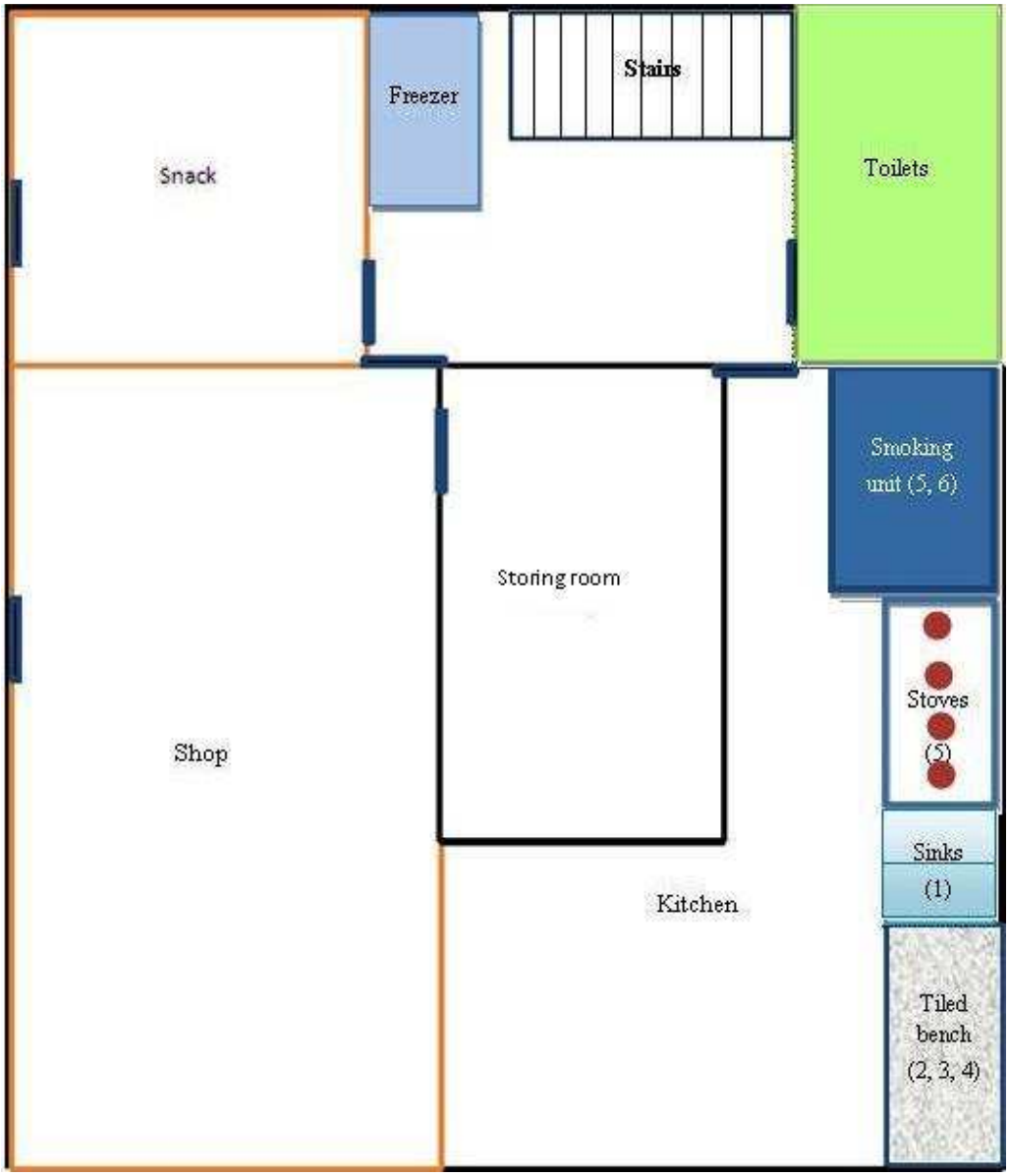


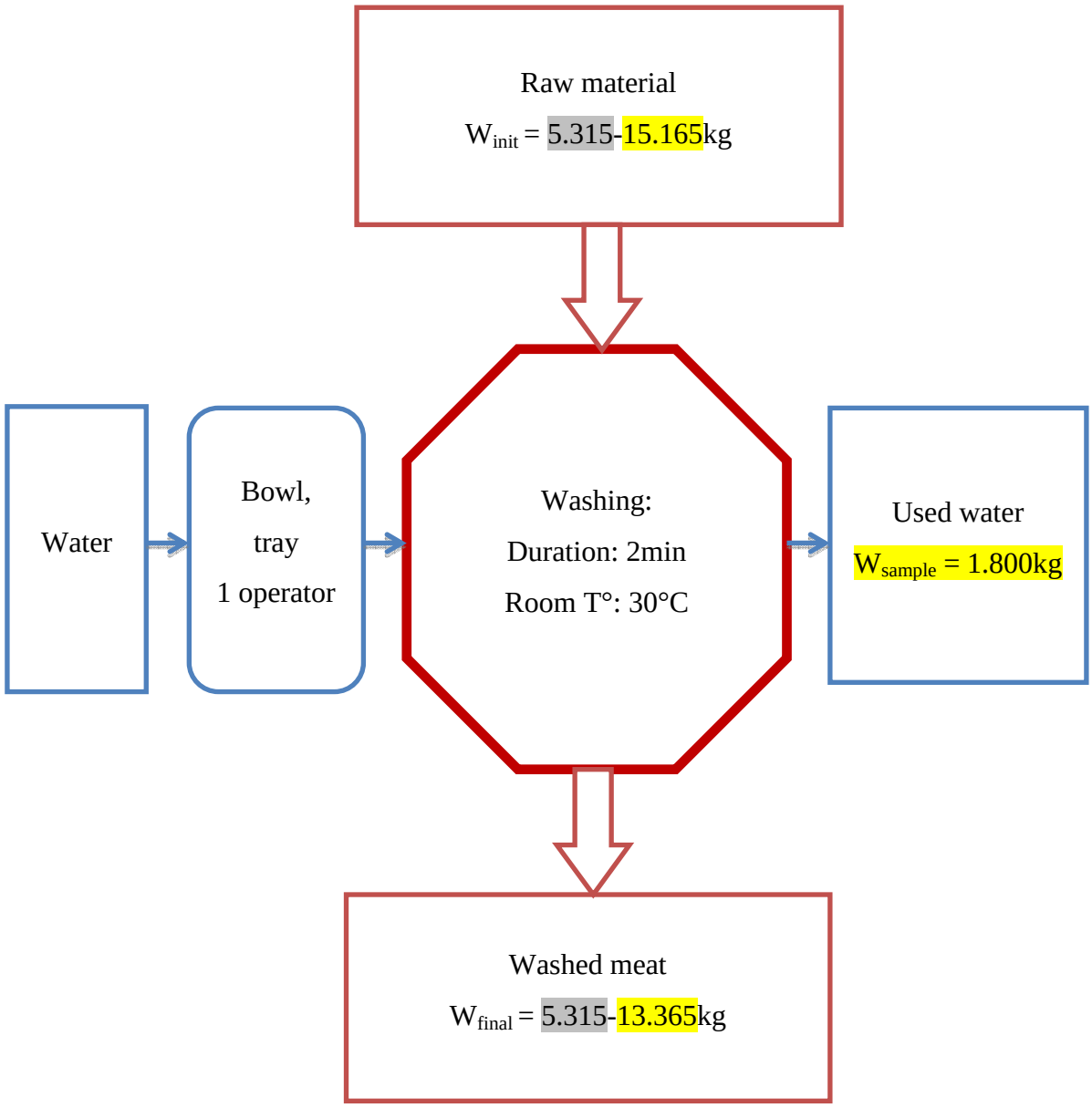
Figure 8: Site type n°2 transformation site

(1 - Washing; 2 - Cutting into strips; 3 - Ingredients adding and mixture; 4 - Marinating; 5 - Smoking 1; 6 - Smoking 2)

Room temperature was measured with a thermometer placed on the bench. Meat was weighed with the shop balance.

d) Documents of step 1: washing

Step diagram



Step quantitative elements

Step qualitative description

The piece used is « thin slice ». Meat comes from the slaughterhouse where animals are slaughtered early in the morning (5 o'clock). Meat is delivered at the shop the same morning near 11 o'clock. During transport, meat is in plastic bags at ambient temperature (between 15-20°C in Antananarivo at this season at this moment of the day). Meat is kept in the freezer -20°C in a plastic bag if not prepared at once. Delivery date and hour are written on the package. Delivered meat is already cleaned from fat and tendons. The day of the visit, meat was deliverd at shop in the morning.

Before washing the meat, the operator washes his hands with soap. The tray and bowl are cleaned with soap and water.

The meat is washed under tap and lied on a tray. This operation lasts about 2min.

It is then submitted to the following step.

Step operator interview

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *No.*

Q3: What are the available energy sources?

Q4: What are the most laborious, dangerous movements?

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how? *All steps can be shortened from time point of view, depending on market constraints.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from?

Q2: Purchased? Where?

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful?

c) Product quality

Q1: What was the previous step? *Raw material reception.*

Q2: Is the product immediately treated? *Not always.*

Q3: If not, in what conditions should it wait (duration, container, temperature)? *It is kept in a plastic bag in the freezer at -20°C. Kitoza is usually prepared before noon or early in the afternoon. There is thus a cold treatement of about 2-4 h.*

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *Meat is washed under tap.*

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products? *Used water goes down the sewer.*

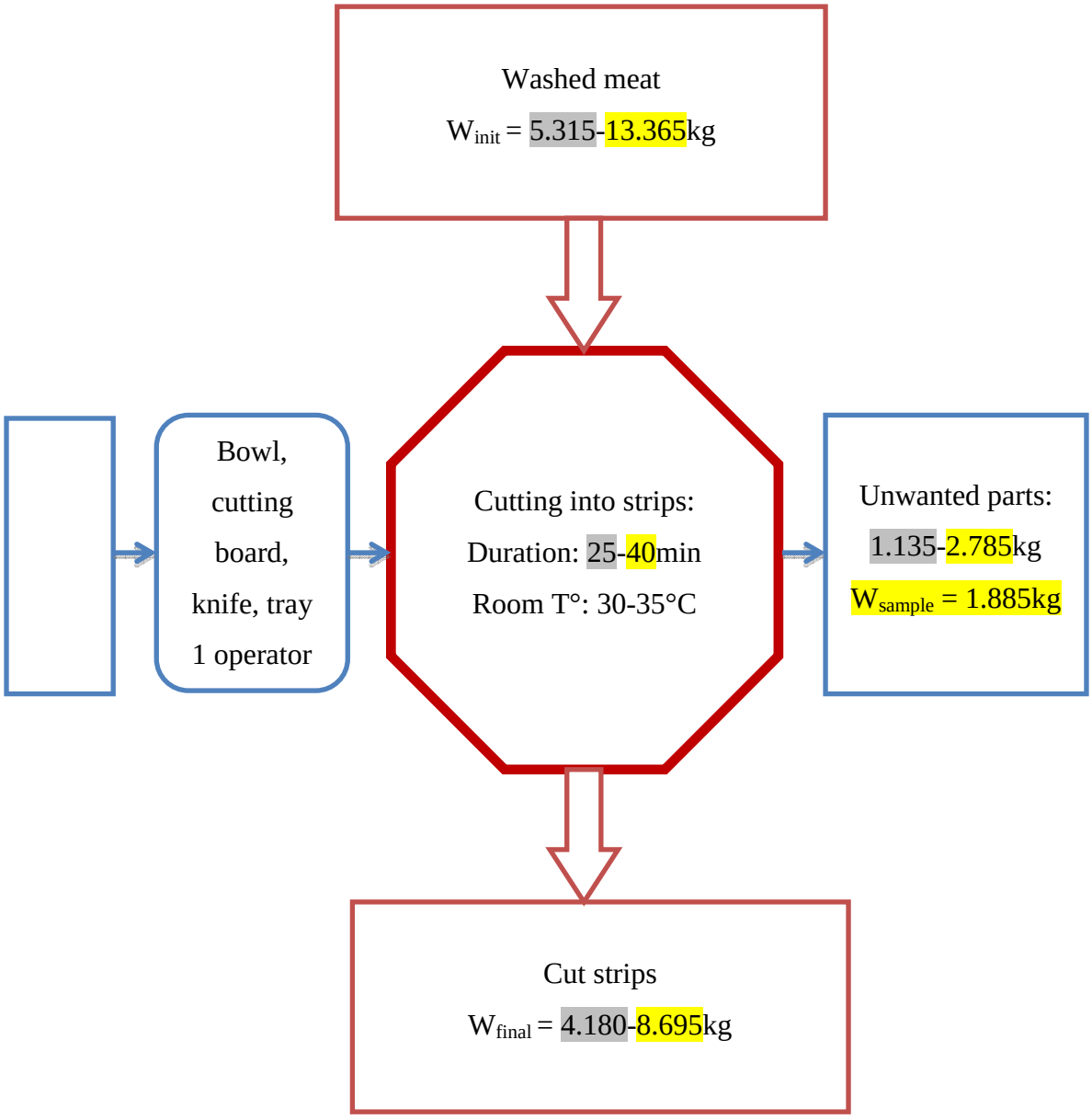
Q11: What is the next step? *Cutting into strips.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

e) Documents of step 2: cutting into strips

Step diagram



Step quantitative elements

Step qualitative description

Cutting strips process is done on a bench that was previously cleaned with soap and water. The knife and cutting board are cleaned as well in the same way.

The piece of meat is first cut perpendicularily to the fibers in 2cm thick slice (Figure 12a)) then in about 20-30 cm long x 2cm thick strips (Figure 12b)). Rejected meat parts (about 21%) are reused for other products such as sausages.

This step lasts about 25 min at about 30°C.

It is then submitted to the following step.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged?

Q3: What are the available energy sources? *Electricity.*

Q4: What are the most laborious, dangerous movements? *There is none since the operator is familiar with the equipment. Cutting strips step may be dangerous for a non trained person since he can cut himself.*

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how? *All steps can be shortened.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify? *The knife cuts well and nothing can replace it.*

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from? *Knives are provided by the manager. The other tools are imported except the wooden cutting board.*

Q2: Purchased? Where? *Knives were bought abroad. The other equipments are purchased in Madagascar.*

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work? *The tray, knife and bowl can be used as long as they are not broken. The knife is changed every two years.*

Q8: What do you do with the tool once it has been no more useful?

c) Product quality

Q1: What was the previous step? *Washing.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached?

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products? *They are used to make sausages or ground meat.*

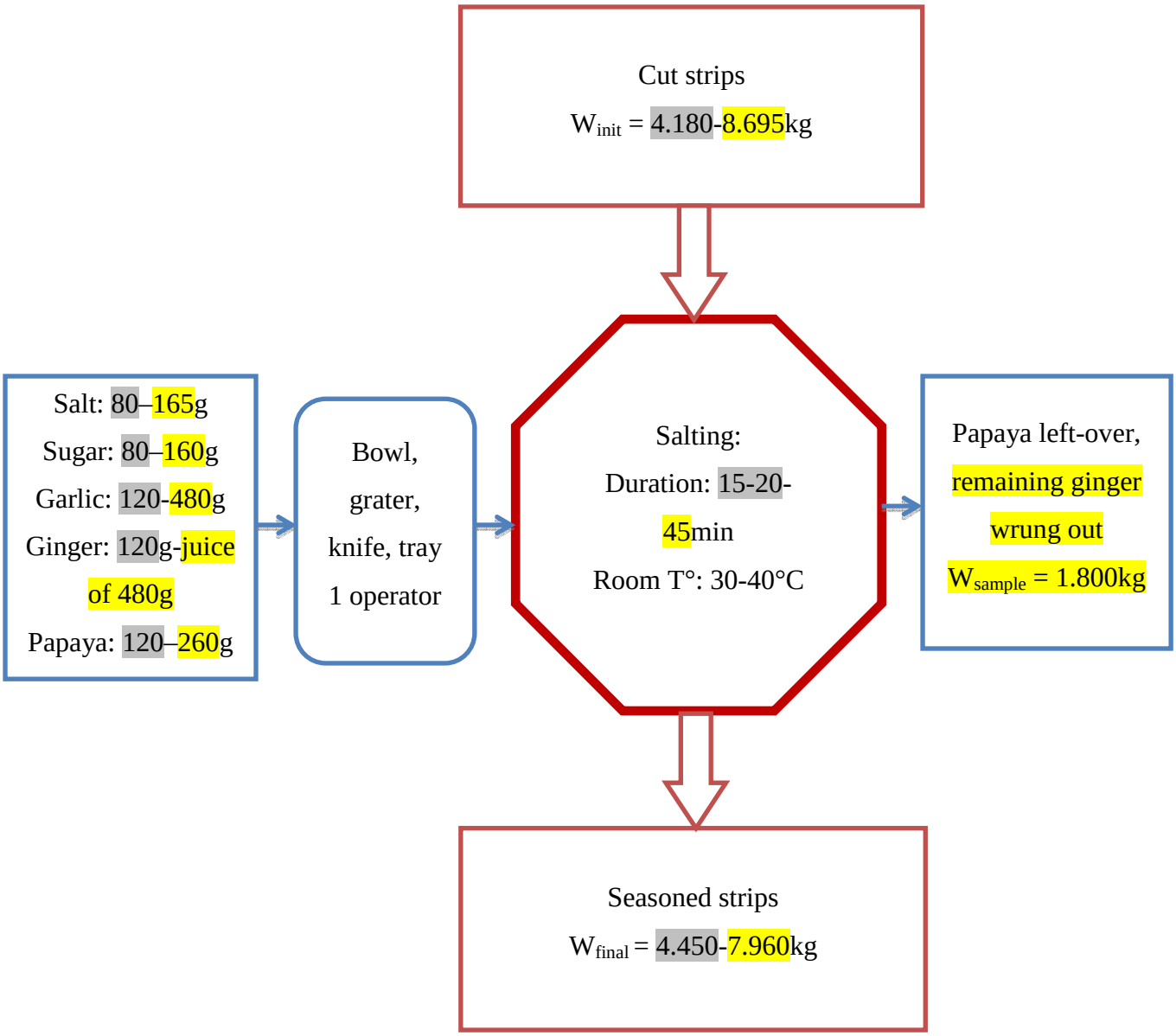
Q11: What is the next step? *Salting.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

f) Documents of step 3: ingredients adding and mixture

Step diagram



Step quantitative elements

The operator weighs ingredients. For salt and sugar, the site responsible recommends a rate of 12 to 16g/kg meat for each ingredient. In the productions we followed, a rate of about 20g/kg was used. For garlic, ginger and papaya, the site responsible recommends a rate of 20 to 25g/kg meat for each ingredient. 28g/kg were used for the first production we followed. For the second one, 55g/kg of garlic and ginger were weighed and 29g/kg of papaya.

Step qualitative description

Ingredients adding and mixing follows the cutting strips step.

Ingredients except salt are delivered at the shop in the morning.

The various ingredients are added. Garlic is previously ground in a mortar. Ginger and papaya are washed with water then grated (Figure 12c) and 12d)). Papaya is grated with its peel. Once grated, they are directly added. Ginger can also be wrung out in a piece of cloth. Then its juice is used in seasoning. Then ingredients and meat are mixed by hand for about 2min (Figure 12e)).

All during these activities, the meat is left at room temperature (30-40°C) in the open air.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *It rarily happens to the ingredients, only when the workers forget to check the stock. Then, we must buy them in the market.*

Q3: What are the available energy sources?

Q4: What are the most laborious, dangerous movements?

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how? *All steps can be shortened.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from? *All equipments are imported.*

Q2: Purchased? Where? *It is all purchased in Madagascar except the knife which is bought abroad.*

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful?

c) Product quality

Q1: What was the previous step? *Cutting into strips.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached?

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products? *Papaya and ginger once wrung out are thrown away.*

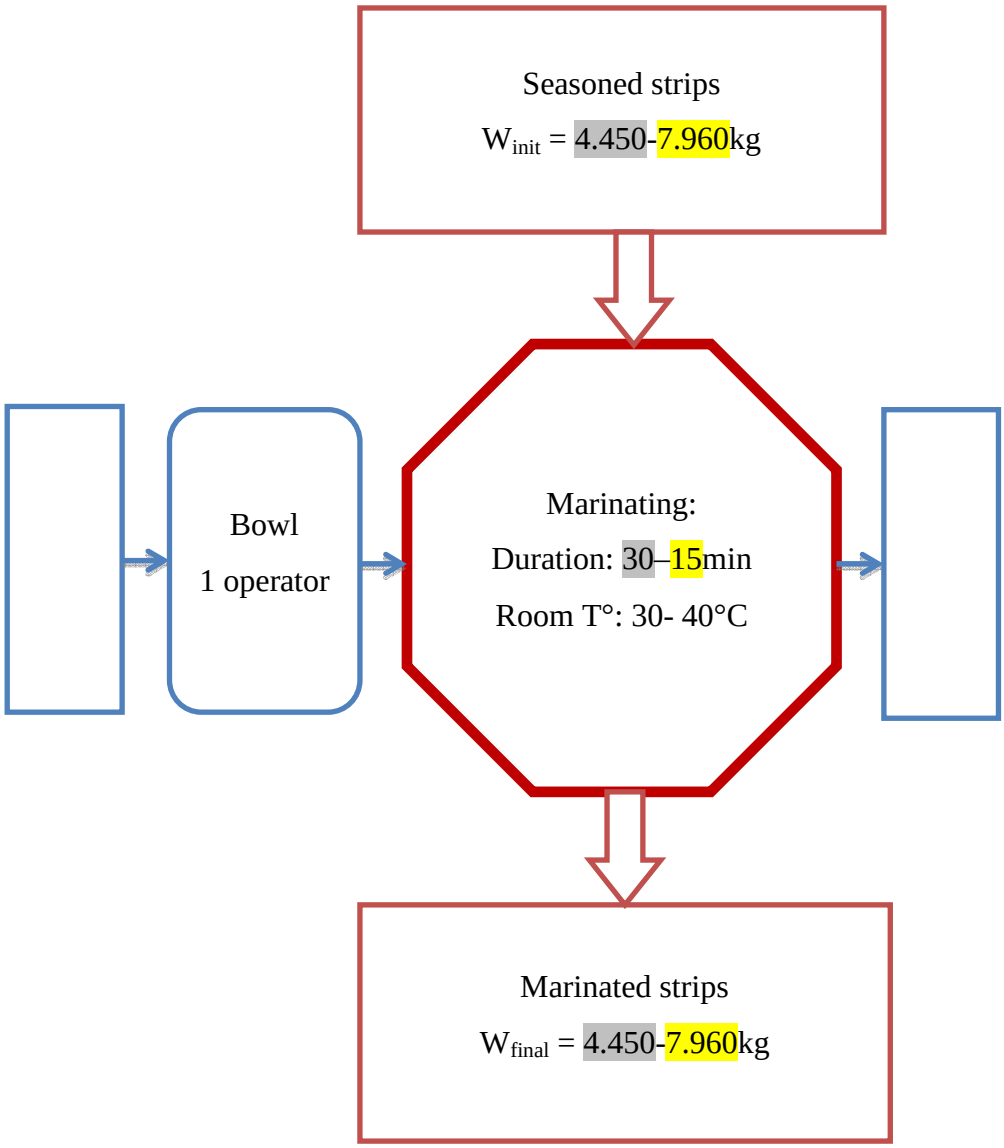
Q11: What is the next step? *Marinating.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

g) Documents of step 4: marinating

Step diagram



Step quantitative elements

Step qualitative description

Seasoned strips are marinated at room temperature (30 to 40 °C) for 15min - 2h according to consumers and trade requirements. In case of need, the step is shortened. This often happens for morning product orders. The operator and the site responsible told us they prefer Kitoza when it is marinated 2 hours.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged?

Q3: What are the available energy sources? *Electricity.*

Q4: What are the most laborious, dangerous movements?

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how? *All steps can be shortened.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from?

Q2: Purchased? Where?

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful?

c) Product quality

Q1: What was the previous step? *Salting.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *You just have to wait for the ingredients well infiltrating.*

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products?

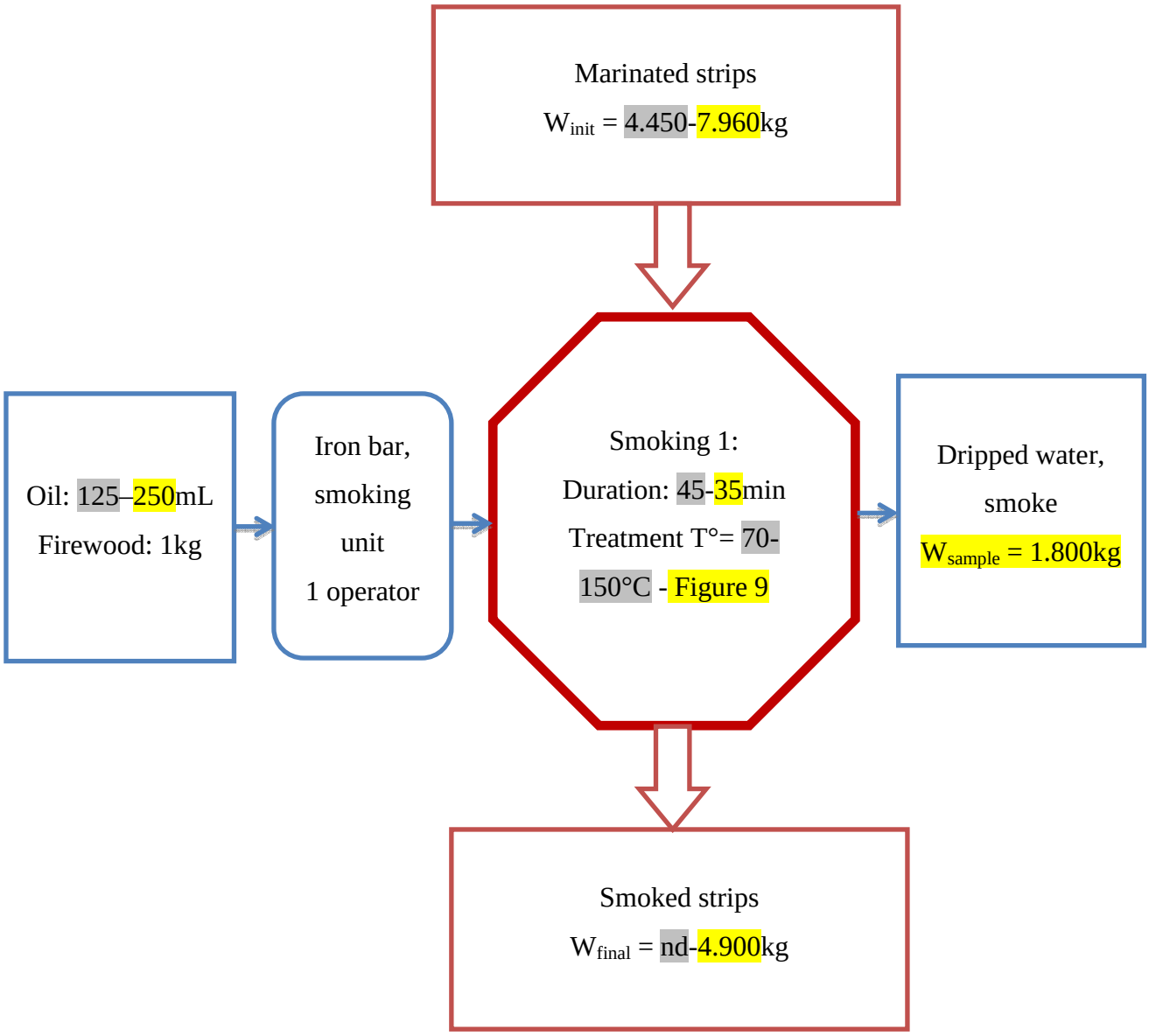
Q11: What is the next step? *Drying.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

h) Documents of step 5: smoking 1

Step diagram



Step quantitative elements

The smoking unit is provided with a thermometer (0-300°C) at the level of the strips. For the first production, treatment temperature was measured with it. Without fire, the inner tempeature is 50°C since the kitchen fire places are nearby. Once the fire is set, the temperature is 70-150°C.

For the second production, treatment temperature was measured with a datalogger. Three probes were used. One was put on the surface of one strip (in 1mm of thickness). The second was put in the middle of a strip, and the third one was placed 10cm below the strips to measure the temperature in the smoking unit. The evolution of temperatures during smoking 1 is shown Figure 9.

The operator measured approximately (knowing the volume of the bottle) the amount of oil 25mL/kg meat.

The amount of firewood was visually estimated.

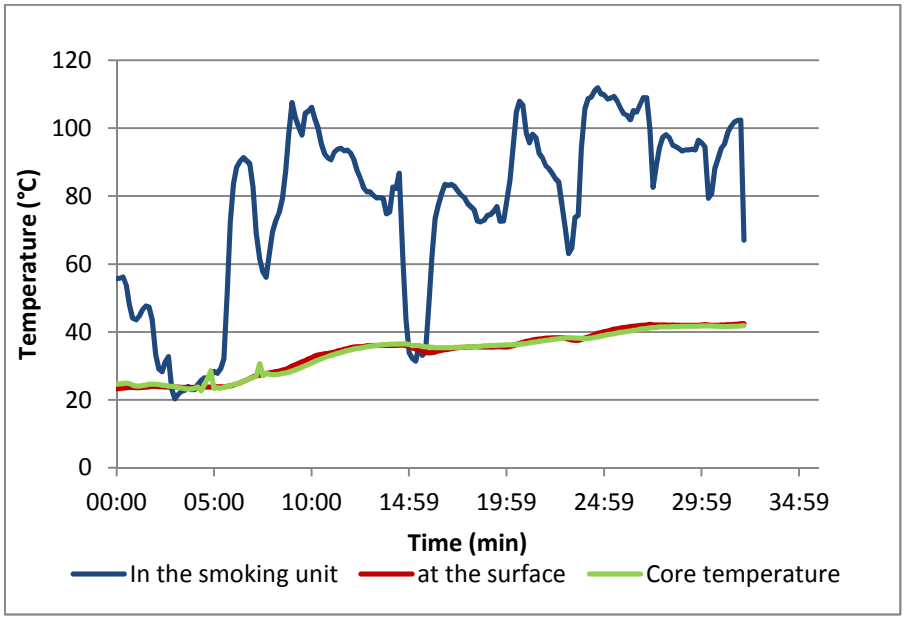


Figure 9: Evolution of temperature during smoking 1 of site type n°2

Step qualitative description

The operator adds firewood in the two stoves located on sides of the smoking unit. Then, the fire is let on. Once the fire is ready, the operator washes his hands with soap.

Before the smoking step, strips are oiled, and mixed by hand for about 2min, in order to keep them soft and kept away from drying. Strips are hung on a bar and introduced in the smoking unit (Figure 12f)) during 45min to 1h depending on market constraints. The temperature inside goes progressively from 70 to 150°C. Until 6 months ago, they were hung above the fire in the kitchen (45-50°C). The operator calls this steps drying.

A shematic representation of the smoking unit is given Figure 10.

The smoking unit is brick made. Smoking unit is 80cm deep and walls are 10cm thick.

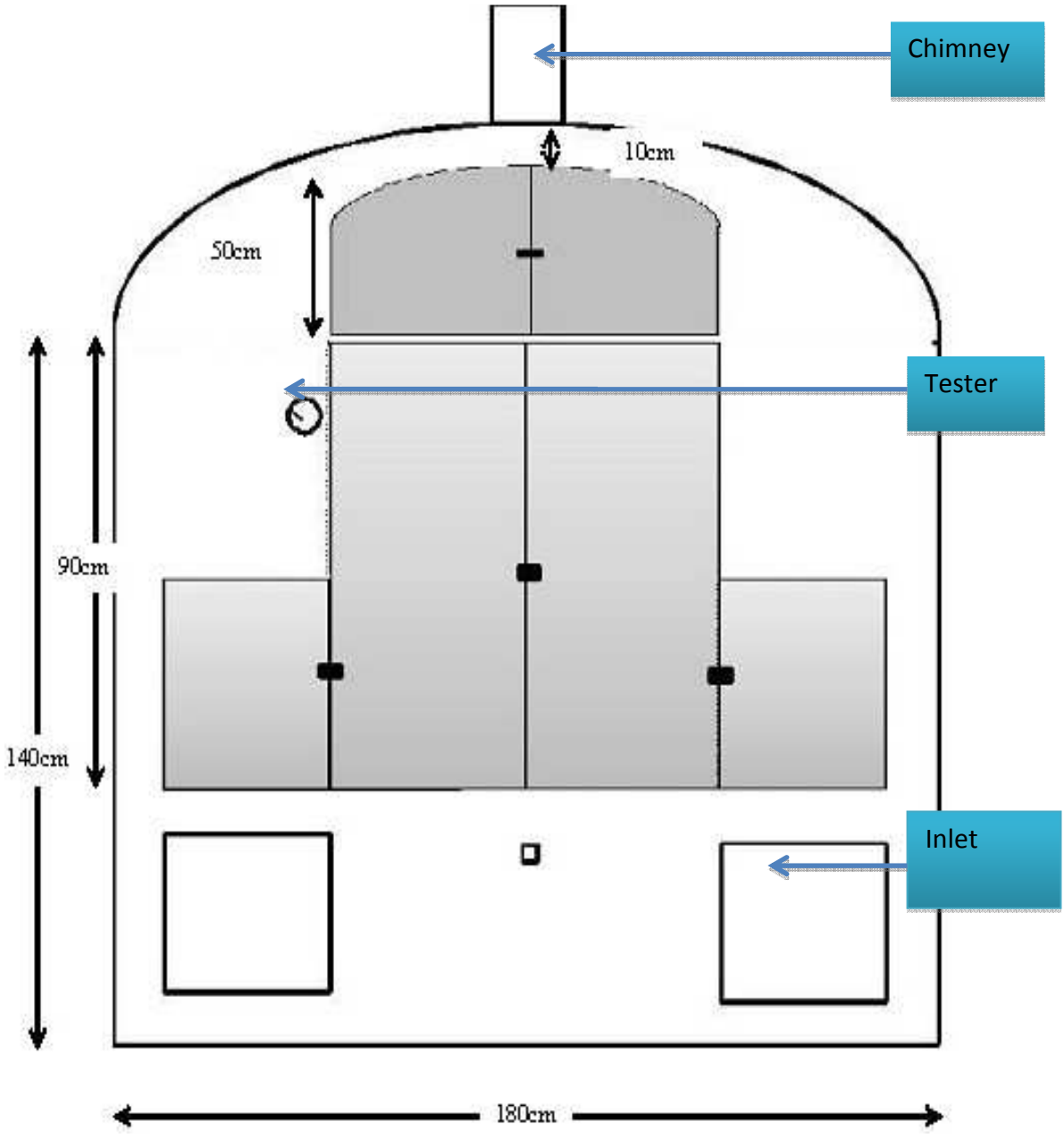


Figure 10: Site type n°2 smoking unit

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged?

Q3: What are the available energy sources? *Electricity, firewood.*

Q4: What are the most laborious, dangerous movements?

Q5: Does the step cause particular harm (noise, smoke, heat)? *No.*

Q6: Can the step be shortened? If so, how? *All steps can be shortened.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from?

Q2: Purchased? Where?

Q3: Locally made? *The smoking unit is locally made.*

Q4: Easy to make? (Can spareparts be found?) *Yes.*

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful? *It never happened to the smoking unit.*

c) Product quality

Q1: What was the previous step? *Marinating.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *Its duration is determined: 45min to 1h.*

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products?

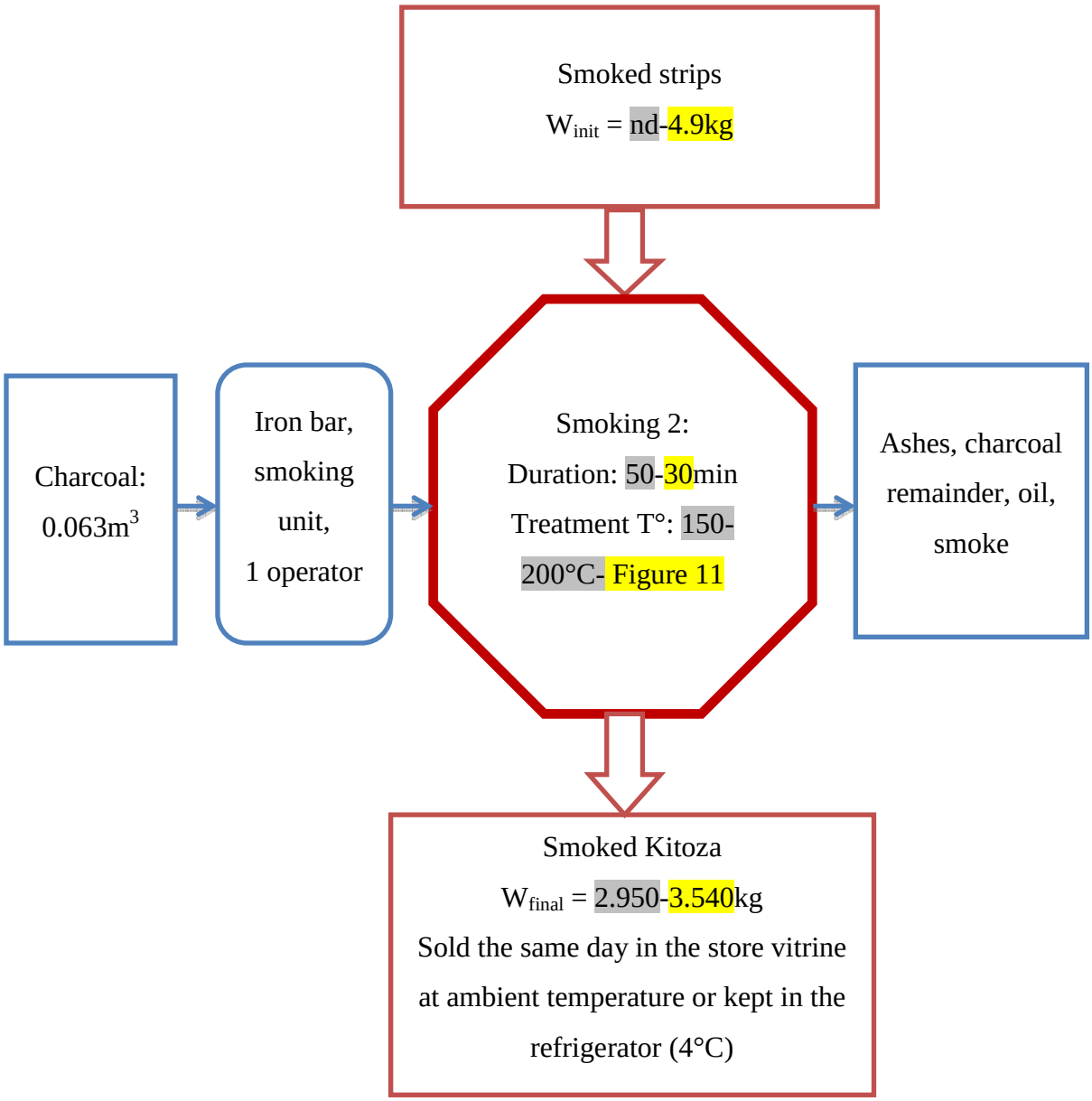
Q11: What is the next step? *Smoking.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

i) Documents of step 6: smoking 2

Step diagram



Step quantitative elements

For the first production, a thermometer (0-300°C) in the smoking unit located at the level of the strips indicates the smoking temperature product.

The 2 stoves located on sides of the smoking unit are half filled with charcoal. Stove dimensions are 70*30*30cm. Charcoal volume used is thus 0.063m^3.

For the second production, treatment temperature was measured with a datalogger. Three probes were used. One was put on the surface of one strip (in 1mm of thickness). The second was put in the middle of a strip, and the third one was placed 10cm below the strips to measure the temperature in the smoking unit. The evolution of temperatures during smoking 2 is shown Figure 11.

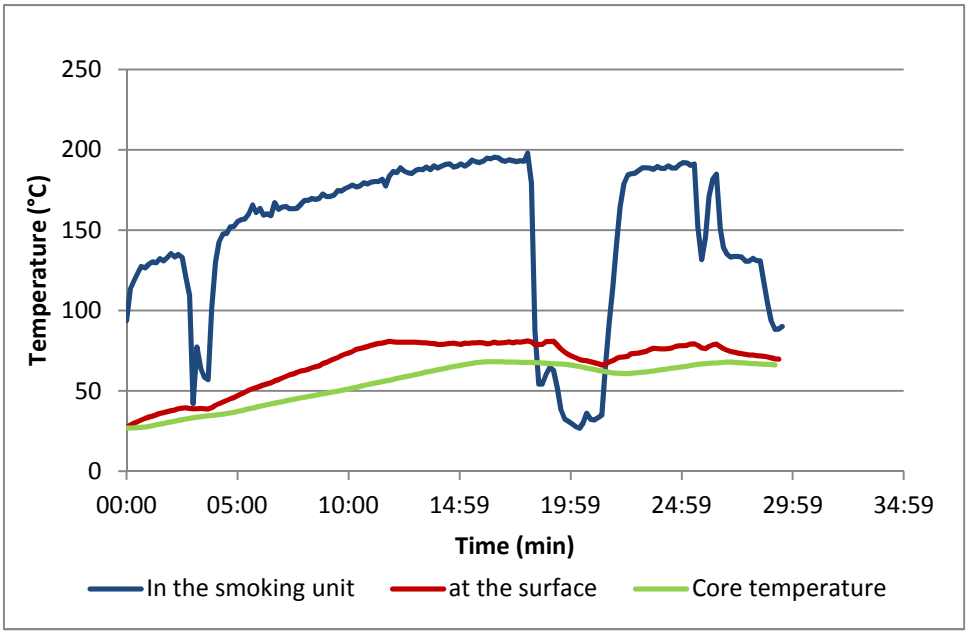


Figure 11: Evolution of temperature during smoking 2 of site type n°2

Step qualitative elements

The second smoking step rather corresponds to a cooking step. The operator adds charcoal in the two stoves located on sides of the smoking unit. In order to avoid direct contact of heat on the meat, an iron plate is diagonally placed above the fire (Figure 12g)). When temperature reaches 200°C (10-30min), 15 to 20min are counted.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged?

Q3: What are the available energy sources? *Electricity, firewood, charcoal.*

Q4: What are the most laborious, dangerous movements? *There is neither laborious nor dangerous operations since the operator is used to handle the materials.*

Q5: Does the step cause particular harm (noise, smoke, heat)? *No, workers are used to kitchen heat and smoke doesn't disturb them.*

Q6: Can the step be shortened? If so, how? *All steps can be shortened.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify? *Yes. The smoking unit works very well.*

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from?

Q2: Purchased? Where?

Q3: Locally made? *It is the smoking unit that is locally made.*

Q4: Easy to make? (Can spareparts be found?) *Yes.*

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful? *It never happened to the smoking unit.*

c) Product quality

Q1: What was the previous step? *Drying.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes, generally.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *The product is smoked during 15 minutes at 200°C.*

Q9: Can the step « fail »? Please be precise. *Strips are rarely burnt.*

Q10: What do you do with discarded products?

Q11: What is the next step? *Sale.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

j) Photos

a) cutting into slices

b) cutting into strips

c) Grating ginger (1st production)

d) Grating papaya

e) Mixing meat and ingredients

f) Meats strips in the smoking unit (smoking 1)

g) Meats strips in the smoking unit (smoking 2)

Figure 12: Photos of processing steps of Kitoza in site type n°2

k) Cost table

Cost table (Table 4) was established.

Table 4: Site type n°2 cost table

Type	Unit	Price
Electricity	KWh (kilowatt-hour)	205 Ariary/kWh 1st trunk 312 Ariary/kWh 2nd trunk
Water	m^3	360 Ariary 1st trunk 1000 Ariary 2nd trunk
Firewood	One cart (« pousse pousse ») content	30000 Ariary/cart
Charcoal	200L sack	15000 Ariary/sack
Workers	Daily paiement	5000 Ariary daily
Raw material	kg	8400 Ariary/kg
Other ingredients	Powdered salt: 200g Sugar: kg Papaya: unit Ginger: kg Garlic: kg Oil: L	Salt: 150 Ariary/package Sugar: 2500 Ariary/kg Papaya: 1000 Ariary/unit Ginger: 4400Ariary/kg Garlic: 3000 Ariary/kg Oil: 5000Ariary/L

Local currency: Ariary; Conversion rate: 1 € = 3000 Ariary

l) Evolution of physico-chemical characteristics during the process

Samples physico-chemical characteristics are presented in Table 5

Table 5: Site type n°2 analysis results

Parameter and unit of measurement	Raw material	Cutting into strips	Ingredients adding and mixture	Smoking 1	Smoking 2
Lipid (g/100g)	2.0±0.6[a] 1.3±0.2[a]	nd	nd	1.4±0.3[a] 0.9±0.1[b]	3.3±0.4[b] 2.0±0.2[c]
Lipid (g/100g dwb)	8.3±2.4[a] 5.5±0.9[a]			4.6±1.0[b] 3.0±0.3[c]	8.1±0.7[a] 5.4±0.4[a]
Protein (g/100g)	23.3±1.2[a] nd	nd	nd	23.9±2.3[a] nd	32.3±0.1[b] nd
Protein (g/100g dwb)	97.8±3.6[a] nd	nd	nd	77.2±7.5[b] nd	79.7±1.5[b] nd
Water (g/100g)	76.2±0.6[a] 77.0±0.6[a]	76.5±0,5[a] 76.6±0.4[a]	72.6±0.1[b] 74.9±0.5[b]	69.0±0.2[c] 70.5±0.4[c]	59.4±0.7[d] 61.9±1.3[d]
Water (g/100g dwb)	320.7±10.3[a] 334.7±11.2[a]	326.2±8.3[a] 326.6±8.3[a]	264.8±1.1[b] 297.9±8.3[b]	222.7±1.9[c] 238.9±4.8[c]	146.6±4.2[d] 162.5±9.1[d]
Salt (g/100g)	nd	nd	1.55±0.05[a] 1.86±0.16[a]	1.82±0.14[b] 2.13±0.15[a,b]	2.41±0.11[c] 2.18±0.13[b]
Salt (g/100g dwb)	nd	nd	5.64±0.17[a] 7.39±0.57[a]	5.87±0.43[a] 7.21±0.50[a]	5.94±0.23[a] 5.73±0.55[b]
Aw	0.988±0.006[a,b] 0.989±0.001[a]	0.989±0.018[b] 0.989±0.001[a]	0.987±0.014[a,b] 0.976±0.000[b]	0.987±0.009[a,b] 0.973±0.004[b]	0.966±0.006[b] 0.968±0.002[c]
pH	5.61±0.18[a] 5.74±0.16[a,b]	5.28±0.02[b] 5.80±0.16[a,b]	5.42±0.02[b,c] 5.81±0.03[a,b]	5.50±0.06[c,a] 5.64±0.02[a]	5.85±0.03[d] 5.87±0.07[b]
Titrable acidity (meq/100g)	13.2±4.1[a] 8.4±0.2[a]	11.1±0.5[a] 9.1±0.5[a]	10.8±1.2[a] 8.4±0.9[a]	10.1±1.8[a] 10.9±0.6[b]	14.0±2.7[a] 15.6±1.8[c]
Titrable acidity (meq/100g dwb)	55.7±18.7[a] 36.5±1.8[a,b]	47.5±2.3[a,b] 39.0±3.1[a,b]	39.5±4.4[a,b] 33.3±4.0[a]	32.6±5.7[b] 37.1±1.7[a,b]	34.4±6.2[b] 40.1±5.2[b]
D-Lactic acid (g/100g)	<0.014[a] <0.014[a]	<0.014[a] <0.014[a]	<0.014[a] <0.014[a]	0.021±0.009[b] <0.014[a]	<0.014[a] <0.014[a]

D-Lactic acid (g/100g dwb)		<0.059±0.001[a] <0.061±0.001[a]	<0.059±0.001[a] <0.060±0.001[a]	<0.051±0.000[a,b] <0.056±0.001[b]	0.069±0.029[a] <0.048±0.001[c]	<0.034±0.001[b] <0.037±0.001[d]
L-Lactic acid (g/100g)		0.73±0.05[a,b] 0.60±0.05[a]	0.79±0.05[b,c] 0.66±0.07[a]	0.71±0.03[a] 0.46±0.06[b]	0.75±0.05[a,b] 0.70±0.03[a,c]	0.84±0.01[c] 0.80±0.11[c]
L-Lactic acid (g/100g dwb)		3.08±0.17[a] 2.61±0.13[a]	3.39±0.27[a] 2.81±0.32[a]	2.61±0.12[b] 1.83±0.21[b]	2.42±0.16[b] 2.38±0.10[a,c]	2.06±0.04[c] 2.10±0.35[b,c]
Glucose (g/100g)		0.072±0.024[a] 0.080±0.029[a,b]	0.251±0.001[b] 0.061±0.058[a]	0.227±0.005[b] 0.164±0.038[b,c]	0.195±0.003[c] 0.390±0.020[d]	0.145±0.017[d] 0.195±0.080[c]
Glucose (g/100g dwb)		0.301±0.095[a] 0.346±0.122[a,b]	1.070±0.023[b] 0.263±0.257[a]	0.828±0.019[c] 0.653±0.158[b]	0.630±0.006[d] 1.322±0.065[c]	0.357±0.038[a] 0.507±0.197[a,b]
Phenols (mg/100g)		0.04±0.06[a] nd	nd	nd	0.06±0.04[a] 0.44±0.04[a]	0.19±0.05[b] 0.40±0.04[a]
Phenols (mg/100g dwb)		1.05±1.03[a] nd	nd	nd	1.02±0.62[a] 1.48±0.15[a]	2.34±0.70[a] 1.05±0.07[b]
PAH (µg/kg)	B(a)A	nd	nd	nd	11.99±4.40[a] 2.55±0.05[a]	9.28±5.53[a] 3.40±0.34[b]
	B(b)F	nd	nd	nd	6.99±1.91[a] 1.35±0.03[a]	3.41±2.18[a] 1.69±0.12[b]
	B(a)P	nd	nd	nd	1.01±0.34[a] 1.70±0.07[a]	1.60±0.16[a] 2.06±0.21[b]
PAH (µg/kg dwb)	B(a)A	nd	nd	nd	38.73±14.45[a] 8.66±0.29[a]	22.75±13.23[a] 8.95±1.18[a]
	B(b)F	nd	nd	nd	22.56±6.26[a] 4.57±0.17[a]	8.34±5.18[b] 4.43±0.40[a]
	B(a)P	nd	nd	nd	3.28±1.12[a] 5.76±0.29[a]	3.86±0.32[a] 5.42±0.72[a]
TBARS (mgMDA/kg)		0.04±0.01[a] 0.39±0.12[a]	0.03±0.00[a] 0.39±0.08[a]	0.35±0.02[a] 0.34±0.03[a]	1.35±0.22[b] 0.41±0.17[a]	5.01±0.83[c] 0.33±0.09[a]
TBARS bs (mgMDA/kg dwb)		0.16±0.05[a] 1.69±0.56[a]	0.13±0.01[a] 1.65±0.34[a]	1.27±0.09[a] 1.34±0.08[a,b]	4.36±0.70[b] 1.41±0.60[a,b]	12.34±1.90[c] 0.88±0.24[b]

dwb: dry weight basis; n=3 samples; the intervals shown are standard deviation; within one line, different letters show significant differences at 95% between steps of process; nd: not determined

Smoking step allows the combination of unit operations of drying which was more marked in the 2nd smoking step with charcoal as cooking. Phenol gain was performed during the 2 smoking steps for the first production although it was more marked in the 1st smoking step for which firewood is used for the second production.

Levels of B(a)P were conform to French regulation (5µg/kg ; 2µg/kg in September 2014). Meat salt content increase due to dry-salting unit operation and due to its concentration because of water loss during smoking. Thus Aw decreases during the process. There was no sign of lactic acid fermentation (as D lactic acid content and titrable acidity dwb did not increase and glucose content and pH did not decrease) in spite of sugar adding at a rate of 2g/100g.

TBARS content in raw material was low and at the end of the process, after smoking step, it increased significantly for the first production. The relatively high value of TBARS index seems to indicate a high degree of oxidation for the final product (5.01±0.83 mg/kg). The non increase of TBARS for the second production could be explained by the use of ginger juice and higher amounts of garlic.

There were no great differences between the 2 productions.

m) Site responsible interview

Questions addressed to site responsible: (if it makes sense)

a) Raw material and intrants

Q1: Where does the raw material come from? It is delivered by the butcher.

Q2: How long before the transformation is it purchased? *In the morning, a few hours after slaughtering.*

Q3: How is it stocked? *In a freezer, in a plastic sachet.*

Q4: How is quality judged? Through its visual aspect: red colour. *The meat is "tranche fine". without tendons.*

Q5: Could it be not fit for transformation? *No, if that occurred, meat would not be accepted.*

Q6: Is the raw material quality important for the quality of final product? *Yes, it is in order to get a final good quality product. That also influences the cost since it is difficult to sale a meat with too much fibers.*

Q7: Could there be any shortage? *Rarely.*

Q8: Can the purchasing cost be a hindrance? *Yes it can because price cant'be increased. Consumers could not afford it anymore.*

Q9: Would it be possible to work with other kind of meat? *No.*

Q10: Could there be an intrant shortage? *No.*

Q11: Could intrants purchasing cost be a hindrance to the activity? *No, only meat price is important. Concerning firewood and charcoal, they are needed only for 10 to 15min.*

Q12: Is it possible to work with other intrants? *No.*

b) Product quality and sale

Q13: Do you have « competitors »? *Yes, we have.*

Q14: If yes, how is your product in comparison to theirs?

Q15: Better of lesser quality? (give precision) *Better than the near rivals.*

Q16: More or less expensive? *Less expensive.*

Q17: What about quality warranty? Do you carry out analysis? *By visual aspect, texture and taste.*

Q18: Are there quality requirements to respect? What are they? *Sanitory quality by organoleptic appreciation (odor, colour, texture).*

Q19: Are end products stocked? *No, major part of production is ordered, otherwise they are not stocked because we know the quantity we can sale in a day.*

Q20: In what conditions. How much is left?

Q21: How far do you sell the products? *No elsewhere.*

Q22: Why don't you export? to the neighboring countries? To Europe? *Internal organization is required: satisfying the demand, supply a sanitary warranty in product delivery: traceability, papers to fill in.*

c) Workshop, manpower and tool conditions

Q23: Is the workshop legally recognized? How? Is it important / mandatory? *Yes, as grocery and snack.*

Q24: Do you receive inspection visits? By whom and how often? *Yes, regular veterinary inpections. At least once a year.*

Q25: Are there any standardised rules for the work and the working areas? *Yes. We spontaneously tiled working areas and use freezer.*

Q26: Is the staff competent? Well trained? *Yes, trained by the manager.*

Q27: Do any steps require a special knowledge and initiatives from the operator? *Yes, but they can't take initiatives and need to be supervised. It depends on work volume.*

Q28: How long does an employee stay at the workshop? *The most ancient have been working here for more than 25 years buy in general rotation in the kitchen lasts 4 years.*

Q29: Why don't you extend the enterprise? *It is on going.*

Q30: Do you intend to renovate the material? Which one and why? *Change smoking unit interior into inox for hygiene and maintenance. In addition, there are kitchen rules today. Build a cool room: there is a difference between a frozen meat and meat stored in a cool room.*

Q31: Could yougive us the approximate prices of process equipment? *Cool room (4m3): 4000000 Ariary; Knife: 15 €; Cutting board: 15 €; Tray: 15 €; Bowl: 20000 Ariary*

Q32: Why don't you make it? *I am short of time and lack funding.*

Q33: Do you have problems with the neighborhood (odors, noise, smoke, other,...)? *No.*

Q34: If so, what are the solutions provided?

The interviews of the site responsible and the step operators allowed to know that each step of processing Kitoza, particularly marinating and smoking, could be shortened, since used meat was already tender and of good quality. No step is laborious since the workers are used to work in the workshop conditions and they master well the technic. Raw material and other intrants quality is carefully controlled.

The site responsible is improving his workshop as much as he can by purchasing higher-performance equipments (balance, kitchen knives, inox tools, cold room, renewing tiles, …). It is his ambition to multiply his outlets sale. All workers employed in the workshop are capable of making Kitoza but one of them has especially been trained.

6) Results for site type n°3 salted smoked pork Kitoza

a) General presentation

The producer also collaborated in the WP1 survey and analysis framework (sample 7) and was part of those selected during sensory analysis of WP5.

The workshop is located at Fiadanamanga (NR 7) and the store, where only delicatessen products are sold, is located at Andoharanofotsy (8km distant). These two areas are in the outlying southern part of Antananarivo. Production site n°3 is a small family enterprise employing one worker. In all, three persons work in the workshop (owners also make Kitoza).

For each production (3 times a week), 2 to 10 kg of Kitoza (only from pork) is produced.

Kitoza sale price is 20000 Ariary/kg.

b) Synthetic traditional transformation diagram

The process applied by this producer is a traditional process with 3 steps (ST) as presented Figure 13.

Figure 13: Site type n°3 transformation diagram and mass balance basis 100kg

c) Transformation site general scheme

Figure 14 shows the plan of the transformation site and the equipments and rooms used for the different steps of Kitoza production. All rooms are at ambient temperature.

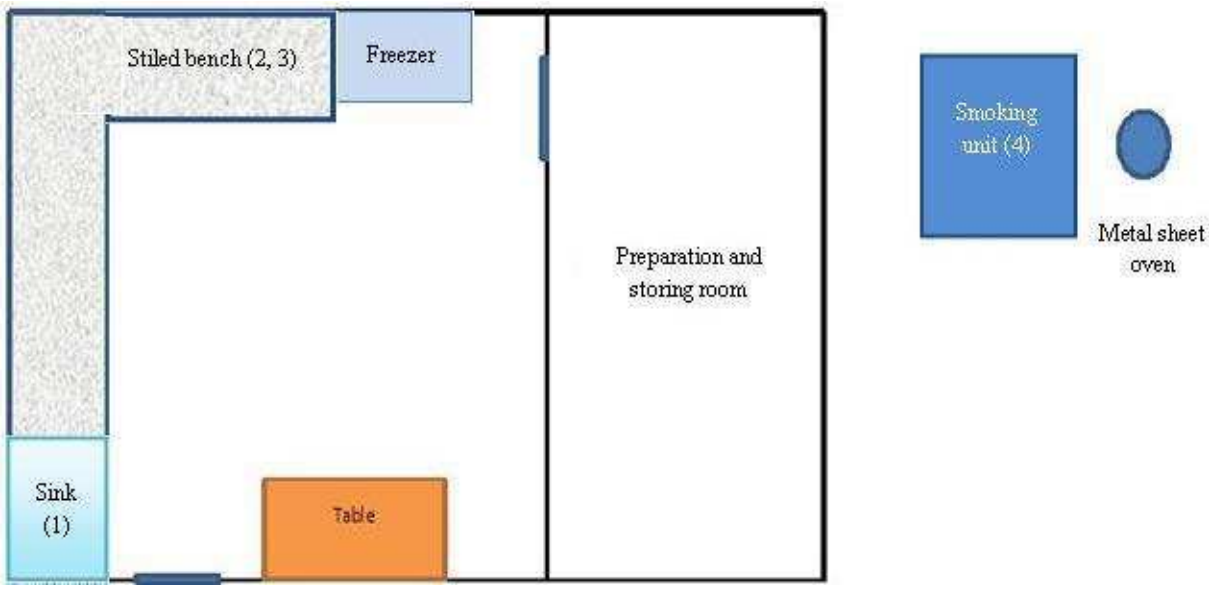


Figure 14: Site type n°3 transformation site

(1 - Washing; 2 - Cutting into strips; 3 - Salting; 4 – Smoking)

Room temperature was measured with a thermometer placed on one of the benches. Meat was weighed with the workshop balance.

d) Documents of step 1: cutting into strips

Step diagram

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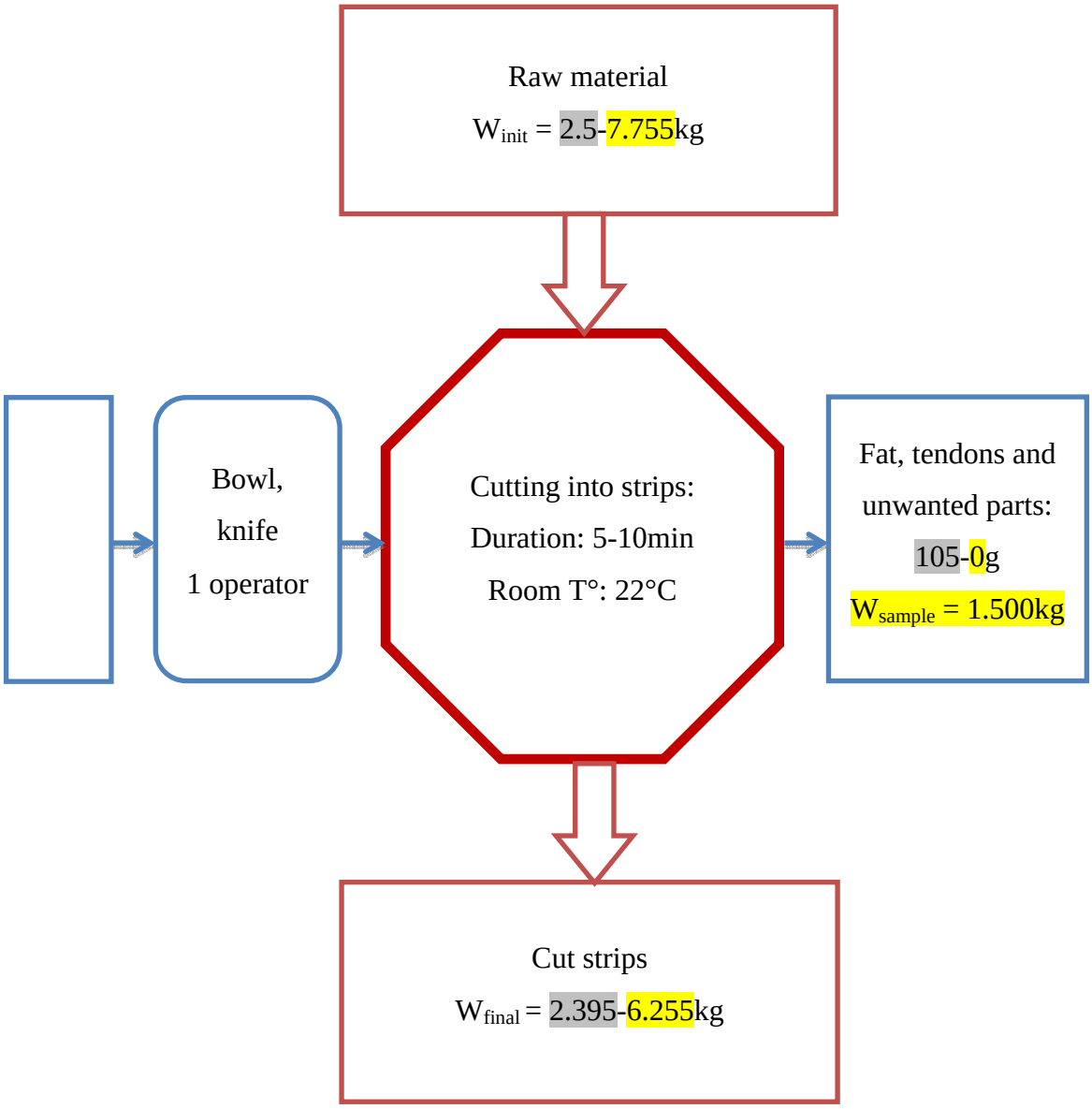


Step quantitative elements

Step qualitative description

Raw material used is pork flesh, especially ham. The responsible site purchases meat in the morning at the meat wholesaler's and transported at ambient temperature (15-20°C in Antananarivo at this season at this moment of the day) by moto in plastic sachets.

The operator washes his hands before cutting the meat. This operation is done straight on the bench which was nearly cleaned with soap and water as all used tools. Meat is cleaned by removing fat and tendons from the flesh (Figure 17a)). Unwanted meat parts represent about 4 to 5% of initial mass. They are reused for other products.

20 to 30cm long x 3 to 5cm thick strips are cut perpendicularily to the meat fibers (Figure 17b).

This step lasts 5 to 10min at room temperature (22°C).

Is is then submitted to the following step.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *No.*

Q3: What are the available energy sources?

Q4: What are the most laborious, dangerous movements? *There is none since the operator is familiar with the equipment. Cutting strips step may be dangerous for a non trained person since he can cut himself.*

Q5: Does the step cause particular harm (noise, smoke, heat)? *No step causes particular harm.*

Q6: Can the step be shortened? If so, how? *No.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify? *The knife cuts correctly and nothing can replace it.*

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from? *Knife comes from local market.*

Q2: Purchased? Where?

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful?

c) Product quality

Q1: What was the previous step? *Meat receipt.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached?

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products? *They are used to make other delicatessen products.*

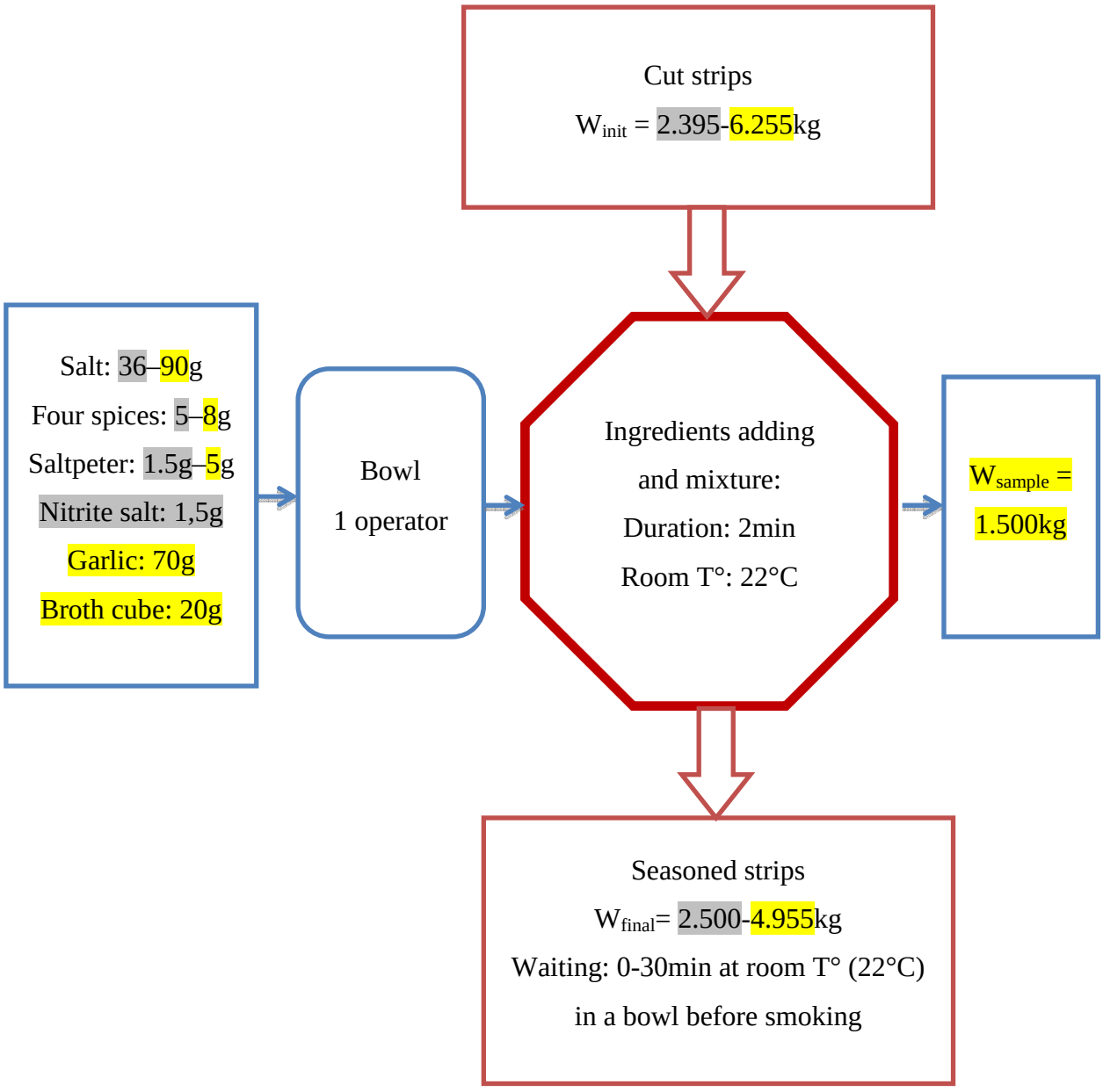
Q11: What is the next step? *Ingredients adding.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

e) Documents of step 2: ingredients adding and mixture

Step diagram



Step quantitative elements

Ingredients were weighed with the workshop balance, except for garlic for wich a handful is used. The recommended quantities in g/kg fresh meat are presented below:

Salt: 15 g/kg

Four spices: 2 g/kg

Saltpeter: 0.5 g/kg

Sel nitrité: 0.5 g/kg

We estimated the weight of garlic.

Step qualitative description

During ingredients weighing, strips are left in a bowl in the open air (2min). Meat and ingredients are then mixed by hand in the bowl during 2min (Figure 17c)). There is neither marinating nor drying step since pork flesh is already tender.

Once salting is over, fire is lit. Lighting fire may take 30min during which strips are in a bowl at room température (22°C).

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *No.*

Q3: What are the available energy sources?

Q4: What are the most laborious, dangerous movements?

Q5: Does the step cause particular harm (noise, smoke, heat)? *No step causes particular harm.*

Q6: Can the step be shortened? If so, how?

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from? *The bowl is an imported product.*

Q2: Purchased? Where? *At the local market.*

Q3: Locally made?

Q4: Easy to make? (Can spareparts be found?)

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful?

c) Product quality

Q1: What was the previous step? *Cutting into strips.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws?

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached?

Q9: Can the step « fail »? Please be precise. *No.*

Q10: What do you do with discarded products?

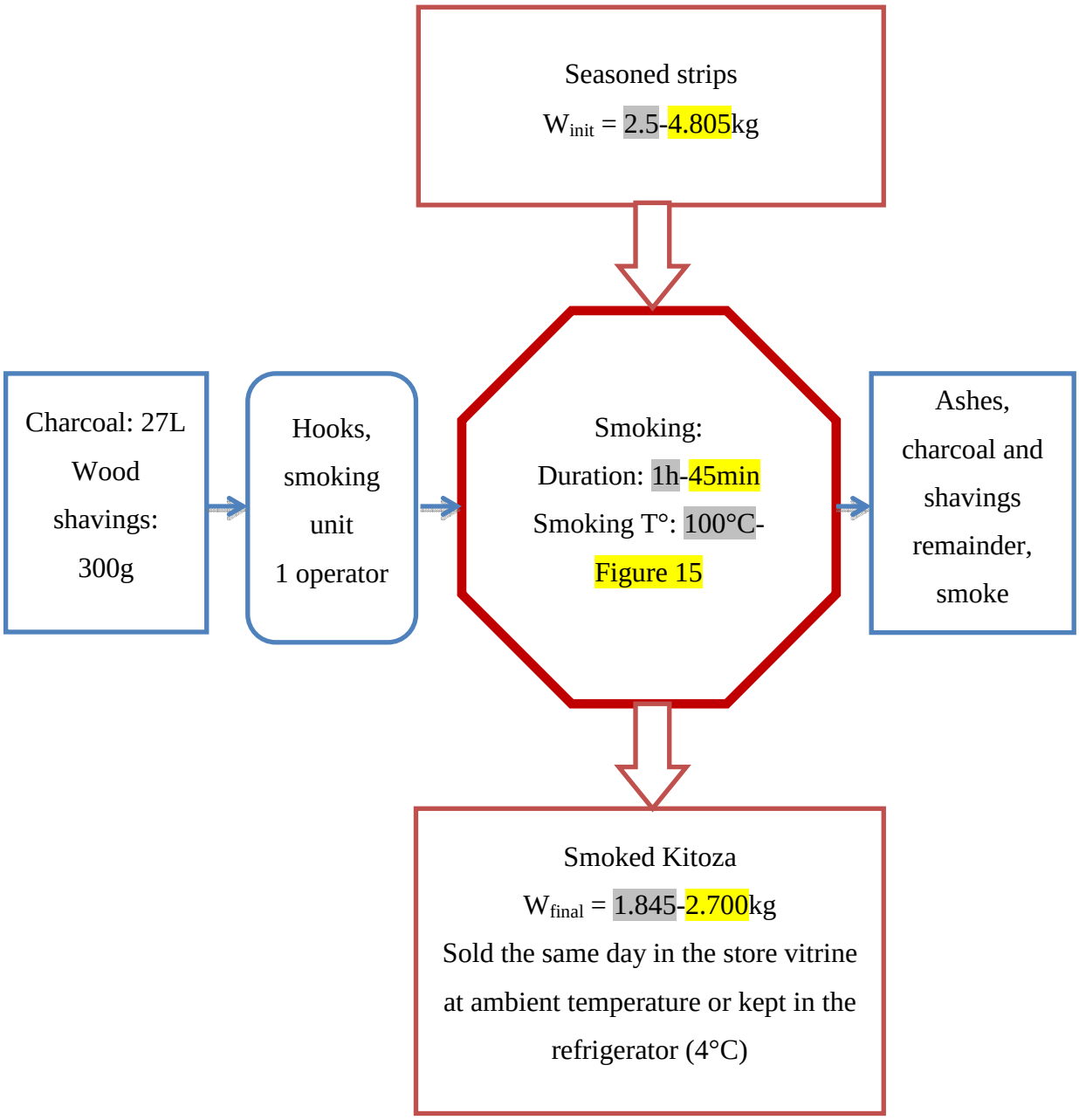
Q11: What is the next step? *Smoking.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise in what conditions should it wait for the next step? (duration, container, temperature)

f) Documents of step 3: smoking

Step diagram



Step quantitative elements

For the first production, treatment temperature was measured with a thermometer (-50-250°C) placed next to the Kitoza strips to keep track with smoking temperature.

For the second production, treatment temperature was measured with a datalogger. Three probes were used. One was put on the surface of one strip (in 1mm of thickness). The second was put in the middle of a strip, and the third one was placed 10cm below the strips to measure the temperature in the smoking unit. The evolution of temperatures during smoking is shown Figure 15.

The volume of charcoal used was estimated knowing the dimensions of the fatapera. 4 handfuls (estimated 300g) of wood shavings were used.

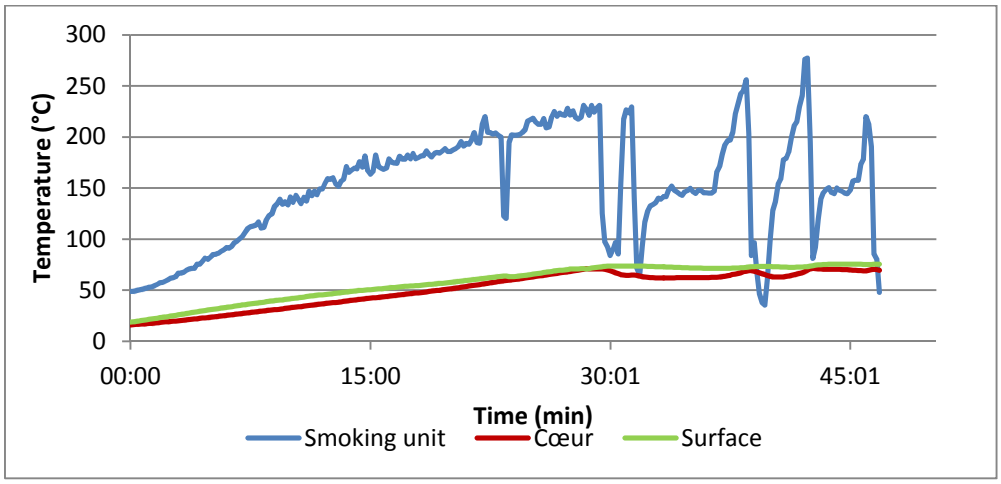


Figure 15: Evolution of temperature during smoking of site type n°3

A shematic representation of the smoking unit is given Figure 16.

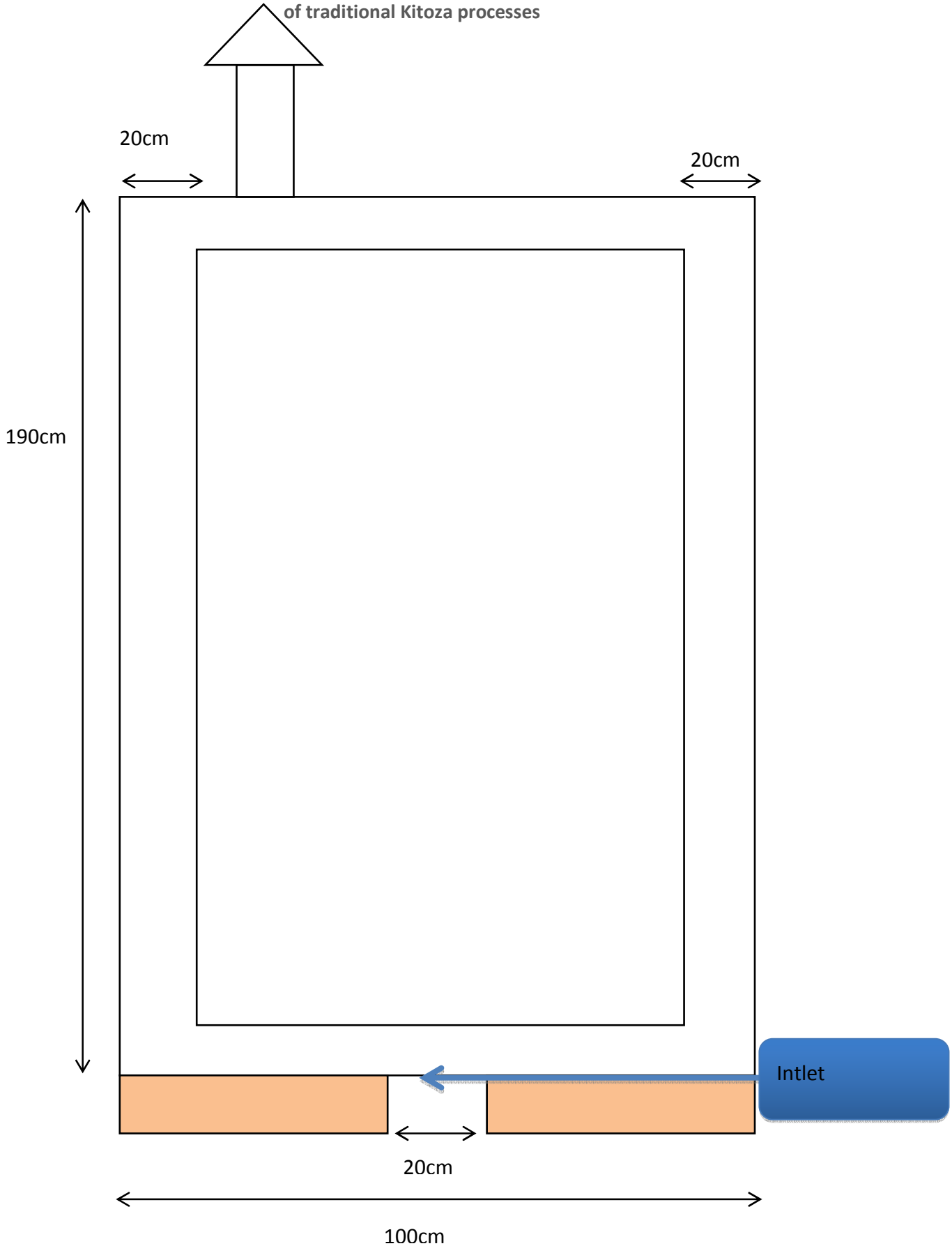


Figure 16: Site type n°3 smoking unit

There is also a drum smoking unit (Figure 17 f) and 17 g)) in the workshop. It is only used for small quantity orders when smoking unit is not lit any more.

Step qualitative description

Smoking follows salting step. In order to light fire, operator puts small pieces of wood in a « fatapera » (artisanal stove), then charcoal above (Figure 17 d)).

Once the fire is lit, the operator washes his hands with soap and strips are hung with hooks which are layered on cross bars. Hooks are put 10cm away from each other.

Smoking is carried out in 2 steps: a cooking step consisting in putting the lit stove in the smoking unit and a smoking step itself during wich wood shavings are added in order to obtain smoke.

Strips are placed at 1.10m above the lit stove. During this cooking step, temperature inside the smoking unit is 100°C. This first step lasts 30min in average. This operation is monitored by opening the smoking unit and observing the visual aspect every 10 to 15min, depending on charcoal quality.

Once meat is cooked, operator put 4 handfuls of wood shavings in the stove in order to add taste and odor to the product. Wood shavings are arranged on an iron plate (« tsikalapatana ») above the charcoal fire (Figure 17e)). This operation needs to be well monitored. Checking the presence of smoke is necessary and flames have to be avoided. If shavings lit, strips would get burnt. Shavings are added if needed. This step lasts 20 to 30min and allows to obtain the red colour of Kitoza.

Once meat is correctly smoked, stove is taken off the smoking unit and the inside is cooled by opening the inlet, so that hooks with final product can be held by operator.

It is worth to mention that Kitoza strips are smoked with sausages wich are produced at the same site. That is to make smoking profitable.

Step operator interview (answers in italic)

a) Functioning

Q1: Can the quantity of treated products change at each production? On what does it depend? *Yes it can. It depends on the (day) sale.*

Q2: Can firewood or water (or other intrants) come to lack? If so, what are the solutions envisaged? *No.*

Q3: What are the available energy sources? *Charcoal.*

Q4: What are the most laborious, dangerous movements?

Q5: Does the step cause particular harm (noise, smoke, heat)? *No step causes particular harm.*

Q6: Can the step be shortened? If so, how? *No.*

Q7: Does the tool or the engine correctly work? Are you aware of a more adapted tool? Please specify?

b) Processing / Assembling / Dismantling / Transport

Q1: Where does the tool / the engine come from?

Q2: Purchased? Where?

Q3: Locally made? *Only brick smoking unit is locally made.*

Q4: Easy to make? (Can spareparts be found?) *Yes.*

Q5: Does the machine need to be dismantable in small parts?

Q6: Does the tool and or machine require to be transportable? Why?

Q7: For how long does it work?

Q8: What do you do with the tool once it has been no more useful? *It never happened to the smoking unit.*

c) Product quality

Q1: What was the previous step? *Salting.*

Q2: Is the product immediately treated? *Yes.*

Q3: If not, in what conditions should it wait? (duration, container, temperature)

Q4: Does the product ends up « with good quality »? *Yes.*

Q5: What are the possible flaws? *Since charcoal quality is not always the same, the product may sometimes be not enough cooked or burnt.*

Q6: Are there times where product is unusable? *No.*

Q8: How do you know that the end of the step is reached? *It is observed through its visual aspect.*

Q9: Can the step « fail »? Please be precise. *Rarely.*

Q10: What do you do with discarded products?

Q11: What is the next step? *Sale.*

Q12: Once the product ready, is it immediately treated at the next step? *Yes.*

Q13: Otherwise, in what conditions should it wait for the next step? (duration, container, temperature)

g) Photos

a) Cleaning the meat

b) Cutting into strips

c) Mixing meat and ingredients

d) Meats strips in the smoking unit

e) Wood shavings on the lit stove

f) Drum smoking unit top view

g) Drum smoking unit face view

Figure 17: Photos of processing steps of Kitoza in site type n°3

h) Cost table

Cost table (Table 6) was established.

Table 6: Site type n°3 cost table

Type	Unit	Price
Electricity	kWh (kilowatt-hour)	248 Ariary/kWh 1st trunk 334 Ariary/kWh 2nd trunk
Water	Well water (Spring water)	
Biomass type: charcoal and wood shavings	Charcoal and wood shavings sack: 1m long and 50cm wide	11000 to 12000 Ariary/charcoal sack 300 Ariary/wood shavings sack
Workers	Monthly paiement	50000 Ariary/month
Raw material	kg	8000 to 8800 Ariary/kg
Other ingredients	Salt: 200g package Saltpeter: 100g package Nitrite salt: 50g package Garlic: concentrate milk tin Four spices: 250g package Broth cube (Jumbo): unit (10g)	Salt: 150 Ariary/package Saltpeter: 1200 Ariary/kg Nitrite: 3000 Ariary/unit Garlic: 900 Ariary/tin Four spices: 250 Ariary/package Broth cube: 150Ariary/unit

Local currency: Ariary Conversion rate: 1 € = 3000 Ariary

i) Evolution of physico-chemical characteristics during the process

Samples physic-chemical characteristics are presented in Table 7.

Table 7: Site type n°3 analyses results

Parameter and unit of measurement	Raw material	Cutting into strips	Ingredients adding and mixture	Smoking
Lipid (g/100g)	8.4±4.0[a] 20.9±9.6[a]	nd	nd	12.9±8.2[a] 7.4±1.9[a]
Lipid (g/100g dwb)	30.1±11.8[a] 79.2±36.7[a]	nd	nd	33.9±21.8[a] 19.9 ±5.0[a]
Protein (g/100g)	20.8±1.1[a] nd	nd	nd	26.4±0.8[b] nd
Protein (g/100g dwb)	75.9±3.6[a] nd	nd	nd	69.4±1.5[b] nd
Water (g/100g)	72.6±2.1[a] 73.5±0.3[a]	66.8±5.0[a,b] 69.8±1.5[b]	55.8±3.6[c] 63.5±0.6[c]	62.0±0.3[b,c] 62.8±0.3[c]
Water (g/100g dwb)	277.7±3.7[a] 73.5±0.3[a]	231.3±16.4[b] 69.8±1.5[b]	174.2±4.6[c] 63.5±0.6[c]	168.6±2.0[c] 62.8±0.3[c]
Salt (g/100g)	nd	nd	1.18±0.16[a] 1.57±0.12[a]	1.87±0.32[b] 1.54±0.07[a]
Salt (g/100g dwb)	nd	nd	2.67±0.28[a] 4.30±0.41[a]	4.92±0.88[b] 4.14±0.16[a]
Aw	0.994±0.011[a] 0.990±0.001[a]	0.988±0.014[a] 0.989±0.001[a]	0.999±0.001[a] 0.981±0.001[b]	0.978±0.014[a] 0.977±0.001[c]
pH	6.78±0.06[a] 5.91±0.09[a]	6.56±0.01[b] 5.93±0.11[a]	6.10±0.13[c] 5.68±0.07[b]	6.22±0.03[c] 5.70±0.01[b]
Titrable acidity (meq/100g)	5.1±0.4[a] 7.0±1.3[a]	7.8±2.8[a] 7.4±0.7[a]	10.0±8.2[a] 7.9±0.6[a]	11.0±0.3[a] 11.3±1.5[b]
Titrable acidity (meq/100g dwb)	18.8±2.69[a] 26.3±4.9[a,b]	23.9±9.3[a] 24.3±1.3[a,b]	22.6±18.0[a] 21.3±1.8[a]	28.8±0.6[a] 30.3±4.2[b]
D-Lactic acid (g/100g)	0.020±0.008[a *] 0.017±0.005[a,b *]	<0.014[a] <0.014[b]	<0.014[a] 0.017[a,b **]	<0.014[a] 0.021±0.002[b]
D-Lactic acid (g/100g dwb)	0.064±0.015[a *] 0.064±0.016[a *]	<0.043±0.006[b] <0.043±0.007[a]	<0.032±0.002[b] 0.047±0.014[a **]	<0.037±0.000[b] 0.057±0.005[a]
L-Lactic acid (g/100g)	0.25±0.02[a] 0.56±0.10[a]	0.30±0.02[a] 0.61±0.03[a]	0.40±0.02[b] 0.70±0.05[a,b]	0.60±0.05[c] 0.83±0.20[b]

L-Lactic acid (g/100g dwb)		0.93±0.09[a] 2.11±0.38[a]	0.90±0.16[a] 2.01±0.01[a]	0.92±0.14[a] 1.93±0.10[a,b]	1.57±0.11[b] 2.24±0.54[b]
Glucose (g/100g)		<0.005[a] 0.069±0.019[a]	0.029±0.002[b] 0.081±0.012[a]	0.036±0.002[b] 0.136±0.019[b]	0.050±0.009[c] 0.169±0.003[c]
Glucose (g/100g dwb)		<0.018±0.001[a] 0.260±0.069[a]	0.089±0.008[b] 0.266±0.029[a]	0.082±0.011[b] 0.374±0.049[b]	0.131±0.022[c] 0.456±0.010[b]
Phenols (mg/100g)		0.01±0.02[a] nd	nd	nd	2.14±0.25[b] 0.60±0.11
Phenols (mg/100g dwb)		0.05±0.09[a] nd	nd	nd	5.62±0.66[b] 1.62±0.29
PAH (µg/kg)	B(a)A	nd	nd	nd	14.49±1.88 2.72±0.26
	B(b)F	nd	nd	nd	94.30±23.88 6.57±0.63
	B(a)P	nd	nd	nd	1.97±0.20 2.38±0.21
PAH (µg/kg dwb)	B(a)A	nd	nd	nd	29.78±5.21 7.31±0.64
	B(b)F	nd	nd	nd	215.34±53.49 17.64±1.57
	B(a)P	nd	nd	nd	9.01±4.65 6.38±0.53
TBARS (mg MDA/kg)		0.02±0.00[a] 0.14±0.01[a]	0.02±0.00[a] 0.10±0.04[a]	0.21±0.00[b] 0.92±0.26[b]	0.02±0.03[a] 0.33±0.10[a]
TBARS (mg MDA/kg)		0.06±0.01[a] 0.54±0.05[a]	0.05±0.01[a] 0.33±0.15[a]	0.47±0.04[b] 2.53±0.71[b]	0.05±0.09[a] 0.90±0.26[a]

dwb: dry weight basis; n=3 samples; the interval shown are standard deviation; within one line, different letters show significant difference at 95% between steps of process; nd: not determined; [*]2 samples/3 were lower than the detection threshold and mean was calculated taking for these samples a value equal to the detection threshold (0.014 g/100g); [**] 1 samples/3 was lower than the detection threshold and mean was calculated taking for this sample a value equal to the detection threshold (0.014 g/100g)

A decrease of water content and Aw is noticed all along the process. Smoking step was short especially the step with wood shavings leading to low levels of phenols but levels of HAP conform to the French regulation (B(a)P<5µg/kg ; 2µg/kg in September 2014). The high temperatre rapidly reach with charcoal during smoking 1 allow the cooking of meat strips.

TBARS levels remain low all along the process.

There were no great differences between the 2 productions except considering the phenol content which was very low (0.60 ± 0.11 mg/100 g) for the second production.

j) Site responsible interview

Questions addressed to site responsible: (if it makes sense)

a) Raw material and intrants

Q1: Where does the raw material come from? *It was purchased at the butcher's.*

Q2: How long before the transformation is it purchased? *1h.*

Q3: How is it stocked?

Q4: How is quality judged? *Meat is stamped by the slaughterhouse vet if quality is judged good.*

Q5: Could it be not fit for transformation? *No.*

Q6: Is the raw material quality important for the quality of final product? *Yes, raw material has to be very fleshy.*

Q7: Could there be any shortage? *No.*

Q8: Can the purchasing cost be a hindrance? *Yes. Sale price could increase so that consumers could not afford Kitoza anymore. Production could thus stop.*

Q9: Would it be possible to work with other kind of meat? *Maybe with mutton meat.*

Q10: Could there be an intrant shortage? No.

Q11: Could intrants purchasing cost be a hindrance to the activity? *Yes, because sale price will have to be increased.*

Q12: Is it possible to work with other intrants? *No.*

b) Product quality and sale

Q13: Do you have « competitors »? *Yes, we have.*

Q14: If yes, how is your product in comparison to theirs?

Q15: Better of lesser quality (give precision)? *Our Kitoza is told to be the best.*

Q16: More or less expensive? *The same price.*

Q17: What about quality warranty? Do you carry out analysis? *By visual aspect and taste.*

Q18: Are there quality requirements to respect? What are they? *Cleanliness, certified meat and cleaned equipment.*

Q19: Are end products stocked? *Yes, during at the most 3 days.*

Q20: In what conditions. How much is left? *In the refrigerator.*

Q21: How far do you sell the products? *At Manakara (950 km south-east), in supermarkets.*

Q22: Why don't you export? to the neighboring countries? To Europe? *It is better to improve locally production.*

c) Workshop, manpower and tool conditions

Q23: Is the workshop legally recognized? How? Is it important / mandatory? *Yes, workshop has "fokontany" and city agreement (tax payment) wich is mandatory.*

Q24: Do you receive inspection visits? By whom and how often? *Yes, by ministry of Health. Last year, they came once.*

Q25: Are there any standardised rules for the work and the working areas? *Working areas have to be tiled.*

Q26: Is the staff competent? Well trained? *Yes, trained by the manager.*

Q27: Do any steps require a special knowledge and initiatives from the operator? *Workers don't wait for order.*

Q28: How long does an employee stay at the workshop? *Six months.*

Q29: Why don't you extend the enterprise? *While waiting for a machine, I have also to find a shop for hire, employees who know how to manage a shop (weighing, giving change).*

Q30: Do you intend to renovate the material? Which one and why? *Yes, the Stanley knife for the sausage forcemeat.*

Q31: Could yougive us the approximate prices of process equipment? *Balance: 1000000 to 120000 Ariary, Freezer 700000 Ariary.*

Q32: Why don't you make it? *It is expensive.*

Q33: Do you have problems with the neighborhood (odors, noise, smoke, other, ...)? *No, moreover workshop was settled down before the other residences.*

Q34: If so, what are the solutions provided?

Since owners also act as workers, there is only one employee in the workshop, so there is no staff problem.

This producer practices the lowest Kitoza sale price (20000 Ariary/kg). He explained that beef Kitoza is more expensive since it is submitted to a more important dessiccation during smoking step. This is the reason why he doesn't make beef Kitoza.

Ingredients for Kitoza processing are supplied by the wholesaler's. Meat quality is warranted by vet stamp. Kitoza production may stop at some periods (march-april, august-september) because of meat shortage and/or price increase. Producer has to stop Kitoza production since he can't raise Kitoza price.

7) Conclusion

For all sites, Kitoza processing includes the following steps: cutting into strips, salting and smoking. The pork Kitoza producer choses not to wash his meat to avoid it fade.

No step is laborious or dangerous for operator since he is used to handle the different equipments. For a non trained person, cutting into strips as well as smoking could be dangerous since he might cut or burn himself. Even if workshops neighbour residences, producers don't encouter problem from inhabitants.

All meat parts discarded during cutting strips are not thrown away but reused for other preparations such as sausage, brawn or minced meat.

Product obtained at the end of a step is always of good quality. Only burnt Kitoza end product can't be sold. But it rarely or never occurs.

The cooking state of Kitoza is visually recognized. This is an empirical estimation but generally smoking duration doesn't vary.

Kitoza production is limited by raw material and ingredient prices. Since producer can't raise his prices, this may affect frequency and quantity production wich even may stop.

Ingredient quantity added to Kitoza don't vary, each site having its own recipe. Commonly used ingredients are: salt, garlic and ginger. Meat is supplied by slaughterhouse or wholesalers, but it need to be stamped by vets.

It is all producers ambition to improve their workshops but they lack funding. Nevertheless, visited workshops obey hygiene rules recommended by ministry of Health, namely tiling working area, owning a freezer and a meat notebook traceability.

International exportation of Kitoza does not appear in producer short term program. They first try to get more outlet sales and introduce their products in supermarkets. One producer sells Kitoza in the south east of Madagascar (950 km from Antananarivo).

According to physico-chemical analyses results, there were no sign of lactic acid fermentation even with the recipe with sugar. The smoking step alowed drying, cooking and smoking of the product with phenols gains that can varies from one producer to another or from one production to another for the same producer. The phenols contents were from 0.19±0.05 to 2.59±0.39 mg/100g. The most smoked/dried products from producer 1 showed the highest levels of HAP due to longer smoking steps. Producer 2 and 3 managed to obtain

low levels of HAP but with lower levels of phenols due to shorter smokig time and the use of charcoal/wood shavings. Reengineering will deal with working on the smoking step in order to obtain products in accordance with consumer's preferences (WP5) in terms of water and phenol contents and with low levels of HAP.