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Introduction

The report covers diversity of processing methods, based on the survey reports submitted by the product champions. The report considers a maximum of three promising processing methods for each product, but in some instances, where deemed necessary, more processing methods may be considered. The different processing methods will also be extracted from the survey reports that are available so far, and the literature review reports that were submitted earlier in the year.

The diversity of processing methods will also be considered in terms of critical control points and hazards associated with the controls. This will be done per product, and product champions are invited to make inputs, so as to develop a holistic picture.

The information in Table 1 to 3 provides brief description of processing methods of products, arranged per group, while Figures 1 to 10 summarises each processing step, and indicates the critical controls areas required for a safe product. This version is the summarised version of the detailed reports which are available.

1. Description of processing methods by products

Table 1: Group 1-Cereal-based Products: Processing methods, raw materials and problems

Product	**Main raw material (ingredient)**	**Processing method 1**	**Processing method 2**	**Processing method 3**
Kenkey-sour fermented maize dough, wrapped in leaves and cooked (Ghana) -Major problem is aflatoxin, mycotoxin from maize and maize husks Spoilage bacteria -Contamination with moulds	-Maize is the raw material -Maize is cleaned by removal of bad grain, foreign material, chaff and winnowing -Another process is settling, where maize is washed in water, and mature kernels sink, and material that floats is removed -Maize that is steeped for 24-48 hours - Maize is milled –The dough is fermented -The dough is wrapped in leaves and cooked Main quality attributes are related to texture, softness, aroma, taste and appearance	-Ga Kenkey, maize dough is fermented for 2-3 days (Short fermentation period) -One part cooked, and then mixed with uncooked dough -Molded into a ball -Salted and cooked wrapped in maize husk for 3 to 3.5 hours -While cooking the balls are covered with a cloth to conserve steam -Shelf life 3-4 days	-Whole maize -Fanti Kenkey, maize dough is fermented for 3-4 days (Long fermentation period) -Not salted Cooked wrapped in plantain leaves, for 3 to 3.5 hours -While cooking the balls are covered with a cloth/sack to conserve steam -The cooked balls have a shelf life of 1 week	-Other types of kenkey from dehulled maize e.g. *Nsiho* and *Fomfom* -Maize dehulled, steeped in water and then milled using an attrition mill -The milled maize is then combined with water and fermented for 24 hours - The balls are then steamed -Nsiho-dehulled maize dough fermented -Fom fom – old dough inoculum is added to shorten the fermentation time to 6 hours

Product	Main raw material (ingredient)	Processing method 1	Processing method 2	Processing method 3
Gowe: Beninese fermented cereal paste, consumed after dilution with water	• Processing method 1: a mixture of malted and non malted maize or sorghum is used • Processing method 2: Only malted maize or sorghum is used • Processing method 3: Only non malted sorghum or maize or the mixture of both non-malted sorghum and maize is used. • For each processing method, the unit operations are quite the same independently of the nature of the raw materials used			
		Mixture of malted and non-malted grains (maize or sorghum) • Cleaning/washing • Soaking • Germination • Sun-drying • Mixture of malted and non-malted grains	Malted maize or sorghum • Cleaning/washing • Soaking • Germination • Sun-drying • Milling • Kneading • Fermentation	Non-malted sorghum and/or maize • Cleaning/washing • Washing • Sun-drying • Milling • Sieving (for mixed grains) • Kneading (for maize or sorghum gowe) • Fermentation • Cooking

Product	**Main raw material (ingredient)**	**Processing method 1**	**Processing method 2**	**Processing method 3**
		• Milling/kneading • Saccharification • Making hot slurry • Fermentation • Cooking of gowé • Packaging • Steam cooking for maize gowé	• Cooking • Packaging	Packaging
	Raw materials and general description	Processing method 1	Processing method 2	Processing Method 3

Product	Main raw material (ingredient)	Processing method 1	Processing method 2	Processing method 3
Akpan (Beninese thirst quenching beverage from fermented maize and sorghum	-Akpan is from sieved fermented maize or sorghum -the fermented Ogi mash is prepared by fermenting cereal -It is essentially a fermented wet-milled maize mash -It is moderately cooked and then mixed with sugar, ice and concentrated milk -Mawe is fermented maize dough rolled into a ball, and sold in the market	-The Maize grain is sorted to remove rotten kernels and then cleaned -The grain is steeped in water (boiled water) -Precooking at 95-100□C for 10 min -Steep for 12-48 hours at 25-35□C -The water is drained from the grain and then wet milled -the milled mash is mixed with water and then sieved to separate the bran -the fine milled grain is then fermented for 1-3 days to form Ogi -Ogi is moderately cooked and prepared to Akpan	-The maize is cleaned and washed. -the maize is milled using a disc mill -The milled maize is sieved to separate the bran -The maize grits are then dampened with water and ground to flour -The flour is kneaded with water to form a dough -The dough is fermented for 1-3 days -the dough is called Mawe -Mawe is sold as a ball in the market	-the maize is pre-cleaned -Maize is then steeped in boiled water for 24 hours -The steeped maize is wet-milled to a fine maize flour -The milled maize is mixed with water and sieved to separate the bran -Fermentation then follows for 24 hours. -The Ogi is separated from the supernatant -The supernatant and water is then added back to the Ogi, mixed and pre-cooked -This is cooled -Ice, conc. Milk and sugar are added to give the Akpan

Product	**Main raw material (ingredient)**	**Processing method 1**	**Processing method 2**	**Processing method 3**
Kishk-Egyptian fermented dry cereal product	Fermented milk and whole wheat grains, salt, cumin seeds	Kishk Sa'eedi: -parboil wheat 4hrs -wash, drain, sun-dry (after sieving) -add buttermilk & spices (e.g.cumin) -ferment 2x24hrs with kneading -cut/shape in chunks/balls -sun dry	Lebanese kishk -parboil wheat (or other cereal) 1hr -wash, drain, sun-dry (after winnowing) -add yoghurt -ferment and knead up to 6x -cut/shape into chunks/balls -sun dry -preserve with oil or as powder	Processing problems: Variability in quality, micro-flora, processes Contamination from utensils and during sun-drying Water quality for washing, diluting

Table 2: Group 2- Meat and Fish products

Product	**Main raw material (ingredient)**	**Processing method 1**	**Processing method 2**	**Processing method 3**
Kitoza (Madagascar)	**The meat**	**Smoked beef kitoza**	**Smoked pork kitoza**	**Consumer produced kitoza**
	-there are two types of kitoza produced: beef and pork -I t is mostly smoked -main ingredients are salt, garlic and ginger. Oil is an option to soften the meat	-meat is cut into strips -washed and marinated(24 hrs) -the strips are dried, and more ingredients are added -final stage is smoking, -exposure to heat and smoke for 45 min to 2 hrs -selling the product	-meat is cut into strips -washed and marinated (24 hrs) -dried and other ingredients added -smoked by exposure to heat and smoke -product is then ready for sale -smoking can be done using a brick smoking oven, or a drum-barrel smoking oven	-meat is bought already cut as strips -The meat is marinated and ingredients added -the meat is then dried, and can also be smoke after drying to produce smoked kitoza
Kong (Senegal) *(Arius heudelotii)*	**The fish**	**Wet smoked kong**	**Dry smoked kong**	
	-this must be fresh fish (catfish) -First step is evisceration and cleaning	-Wet smoked kong is preferred because of taste - Problems assoiciated with wet smoked kong include: rapid spoilage, maggots and	-Dried smoked kong is smoked until the fish is dry -Dried smoked kong preserves better and can be sold at far	

Product	Main raw material (ingredient)	Processing method 1	Processing method 2	Processing method 3
	-sea water is important, or salt in water	high total volatile nitrogen (TVN) -the important attribute of kong is colour and flavour	way places -the main problem of smoking is the presence of benzopyrene (HAP) -Mould growth on the dried product can also be a problem, if it is not properly stored	
Lanhouin fish (Benin) species include: croaker, threadfin, mackerel highly flavoured and used as a condiment in some dishes; also as food eaten with kenkey in Ghana	**The fish**	**Process 1**	**Process 2**	**Major problems**
	-the fish is spontaneously fermented by mostly the gram positives -uncontrolled\ -flavour production -High levels of histamine- a problem?	-various fish species are processed to lanhouin (literally translated to mean smelly fish) -fish is gutted, and left at room temperature for a day -the seemingly spoilt fish is salted and covered with old clothes of paper and left to ferment for 3 to 8 days -washing -sun drying	-the whole fish is ripened in sea water for day -the fish is then gutted and fermented as in Processing method 1.	-unhygienic conditions-dirty water etc -larvae -insect infestation -moulds -bacterial spoilage and high levels of histamine -packaging

Table 3: Group 3- Plant based extracts as functional foods

Product	Main raw material (ingredient)	Processing method 1	Processing method 2	Processing method 3
Boabab (Buy) [*Adansonia digitata*]-Senegal	**Dried, mature baobab fruits**	**Juice**	**Dried pulp**	**Dishes containing baobab pulp**
	-The mature fruit is dry, and can be marketed as such -preferred attribute is the dryer the fruit the better	-Fruit broken to release pulp, which is then cleaned. -Soaking of pulp in water, mixing and filtration -juice produced after addition of sugar -filling of juice into bottles -short shelf life-3-4 days	-pulp is prepared from the fruit -The pods are broken using a stick or hitting against a wall -The pulp is separated from the seeds	-Pulp is added to porridges -Luxury dishes such as "Ngalax" (baobab pulp with steam rolled millet flour)
Bissap [*Hibiscus sabdariffa*] (Senegal)	**The Calyx, harvesting and drying**	**Juice**	**Bissap leaves**	**Processing problems**
	-Calyx is harvested, and dried, usually sun-dried -Packaged in bags, and transported to urban areas or various destinations	-Cleaning and soaking of calyx in water -filtering -addition of other ingredients (sugar,	-dried leaves are added to meals by women to improve taste of the meal	Manual decortification of the calyx and bottle filling, contamination during sun-drying, moisture uptake, calyx and juice discoloration

Product	Main raw material (ingredient)	Processing method 1	Processing method 2	Processing method 3
	-Red variety (Vimto) of calyx is popular -Problems in storage associated with moisture uptake from humid environments -max storage is 3 years	flavouring) -bottling and refrigeration -short shelf life, 1-5 days		
Jaabi, [*Ziziphus mauritiana]* (Cameroun)	**The fruit**	**Jaabi flour**	**Yaabande cake**	**Processing**
	-The mature and dry fruit falls from the tree, and then harvested -Harvesting is in November to January -there are 4 varieties of jaabi - *Jaabi lammuji* and *Jaabi dakamji* are the varieties mostly preferred by population for their sweet taste	-Jaabi grains are pound to flour, -The core and peels are removed by sieving -There are four varieties of jaabi, two are popular, while the other two are used during periods of food scarcity	-produced exclusively from *Jaabi lammuji* and *Jaabi dakamji* -Jaabi flour is produced as described by pounding the grain -The jaabi flour is sprinkled with water -There are four methods of processing based on tribal practices	-Diversity of processing based on tribal practices -Need to consider conservation -Problem with sun drying is contamination with dust, which introduces a gritty texture to the cake - correct flour: water ratio before roasting/cooking is essential - Other quality problems are associated with burning of the cake

Product	Main raw material (ingredient)	Processing method 1	Processing method 2	Processing method 3
	-Jaabi grains are stored in bags- jute of plastic -They can be stored for up to 3 weeks -problem with high humidity and insect attack		-The flour-water mixture is moulded into a calabash which is then wrapped vegetal leaves - Roasting on fire -Vapour cooking -Sun drying	

2. Identifying Critical Control for each product

Group 1: Cereal Products

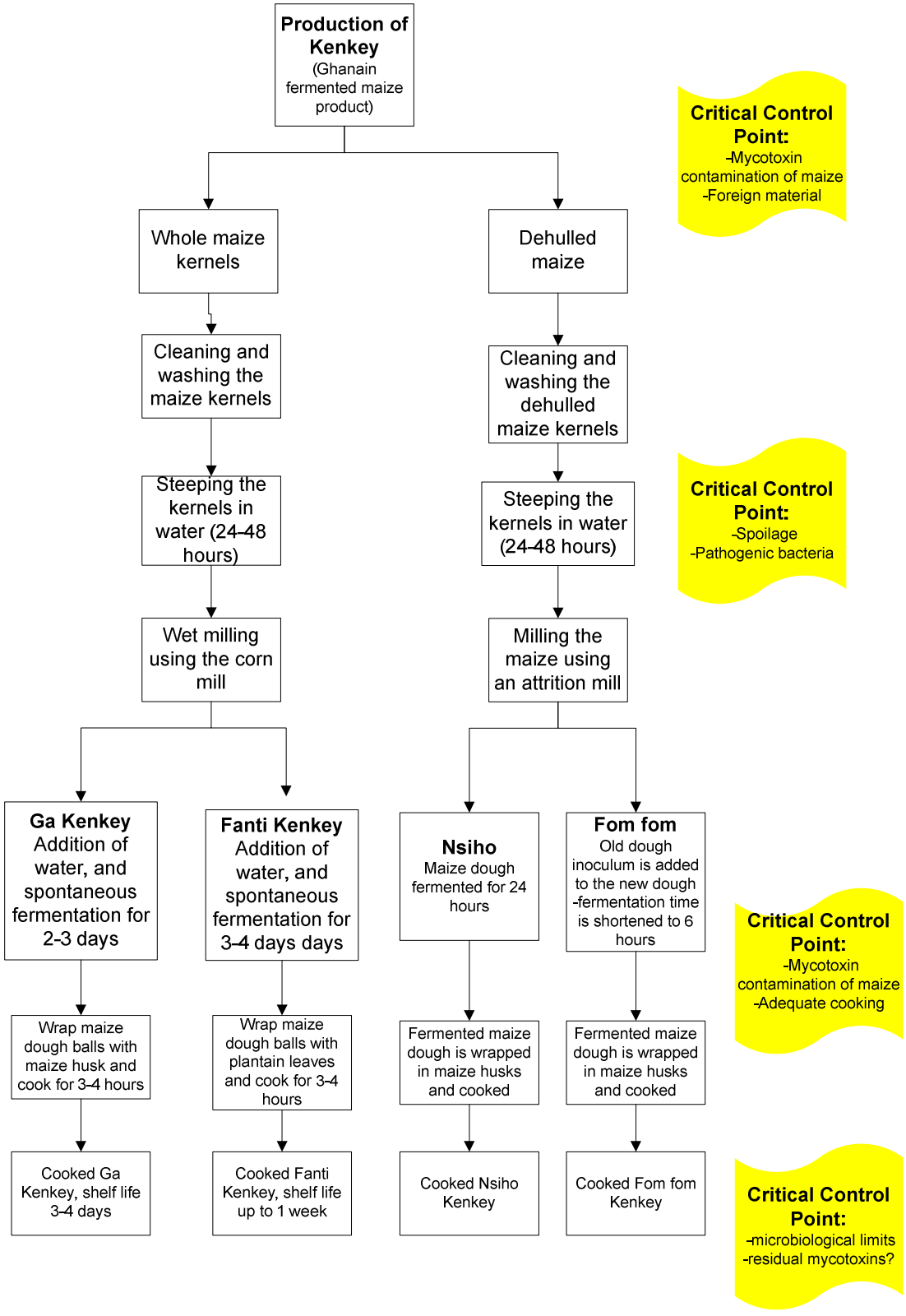

Fig 1: Flow diagram of Kenkey processing and suggested critical control points

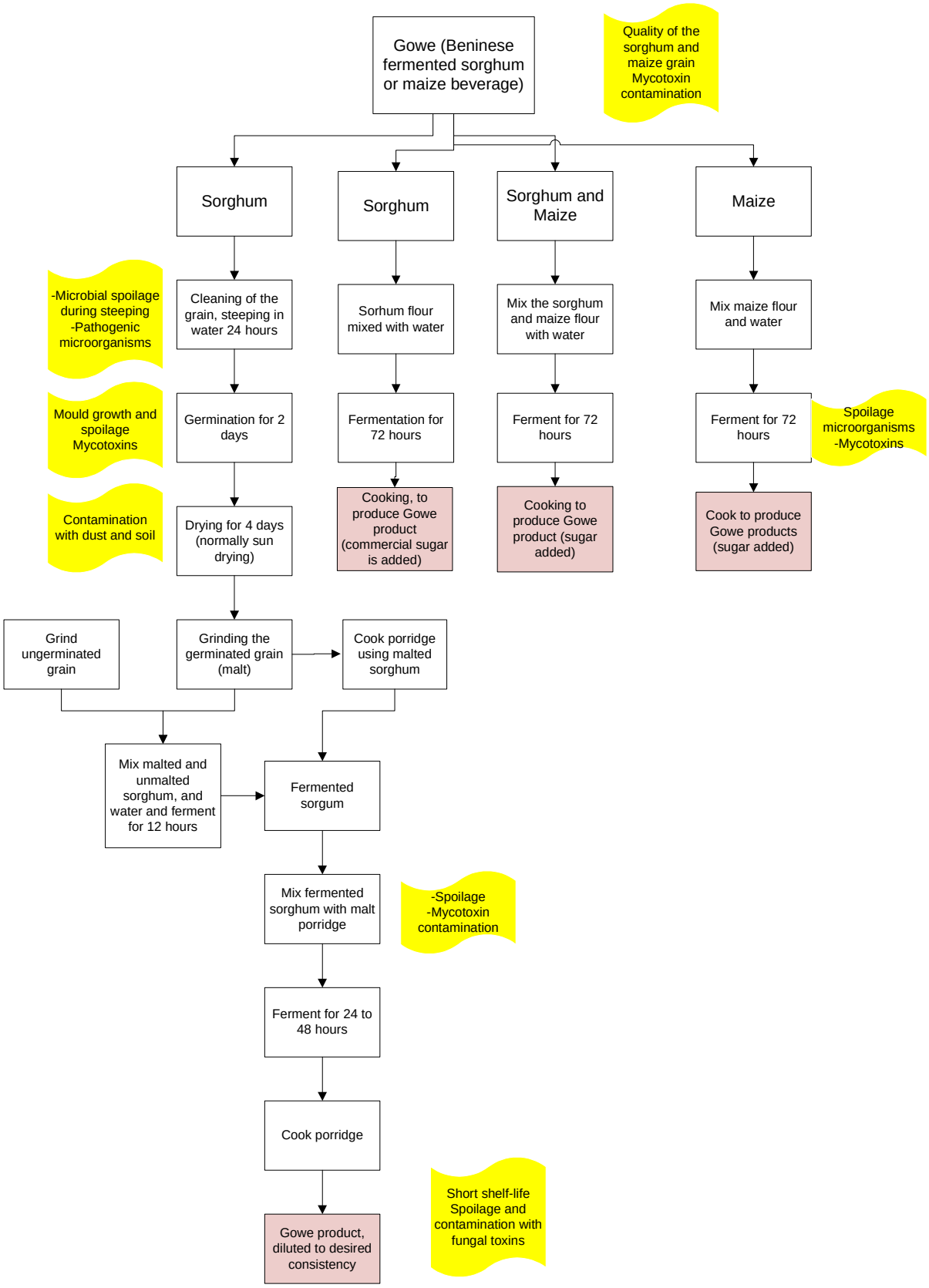

Fig 2: Flow diagram of gowe processing and suggested critical control points

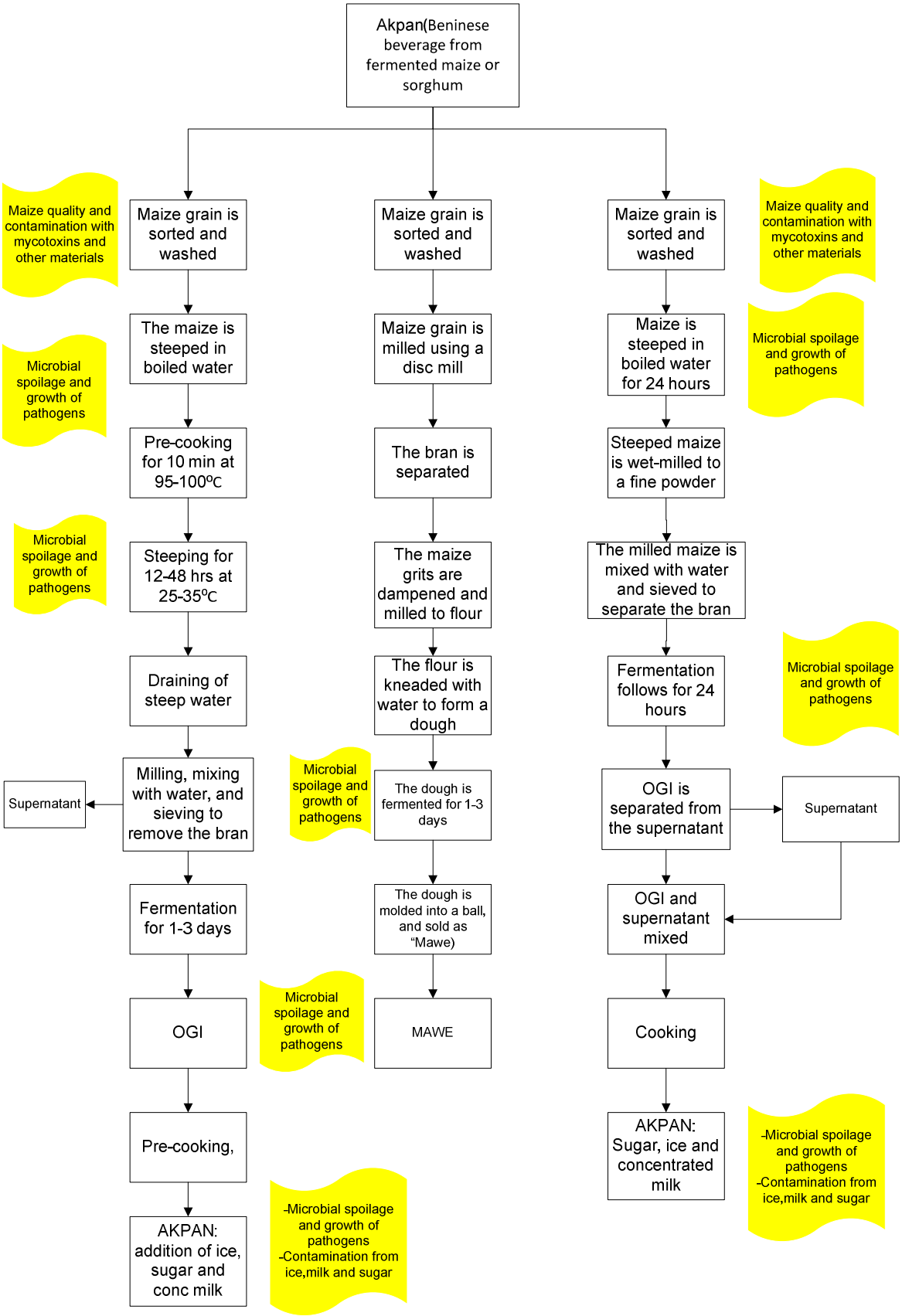

Fig 3: Flow diagram of akpan processing and suggested critical control points

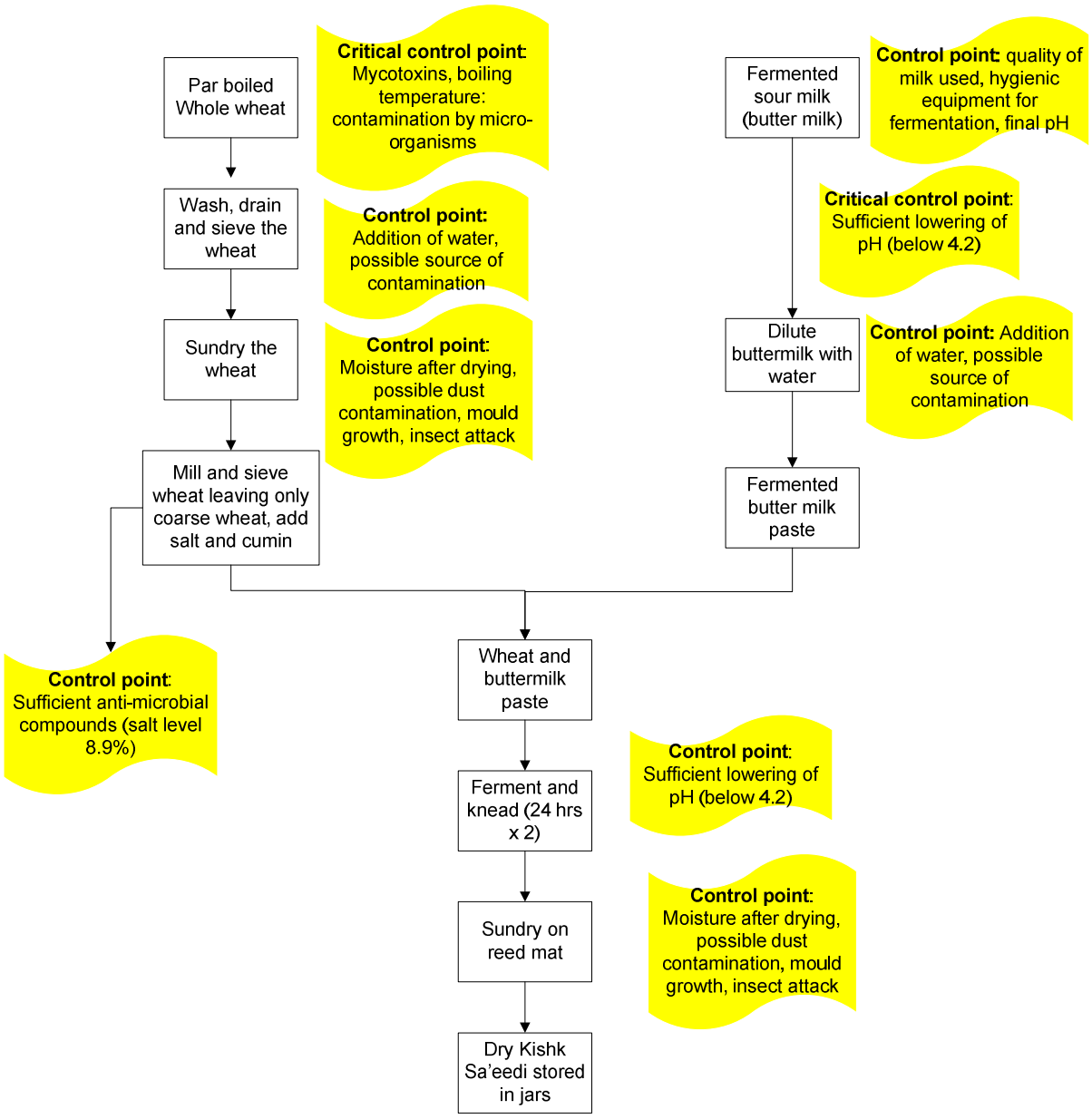

Fig 4: Flow diagram of Kishk processing and suggested critical control points

Group 2: Meat and fish products

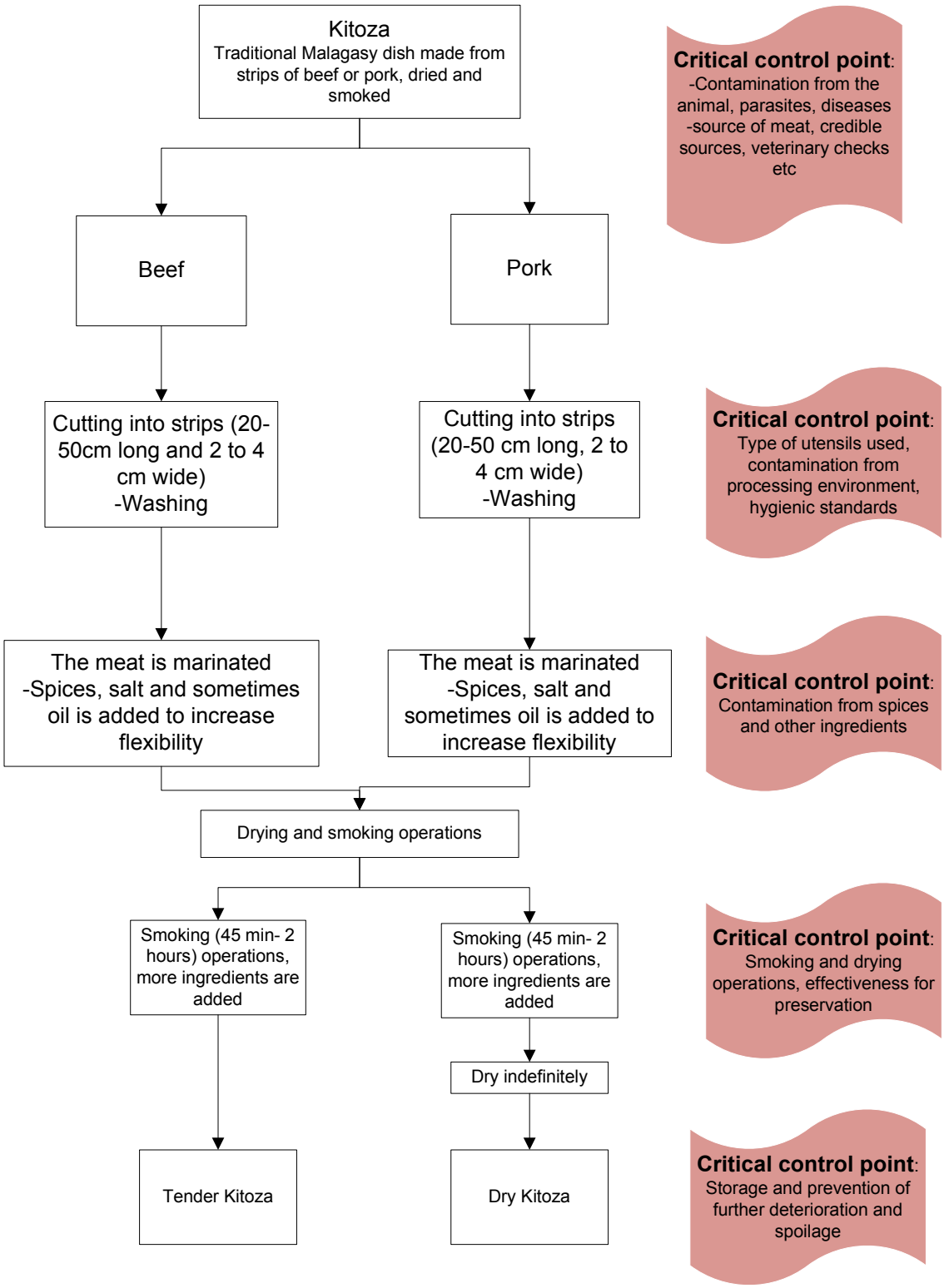

Fig 5: Flow diagram of kitoza processing and suggested critical control points

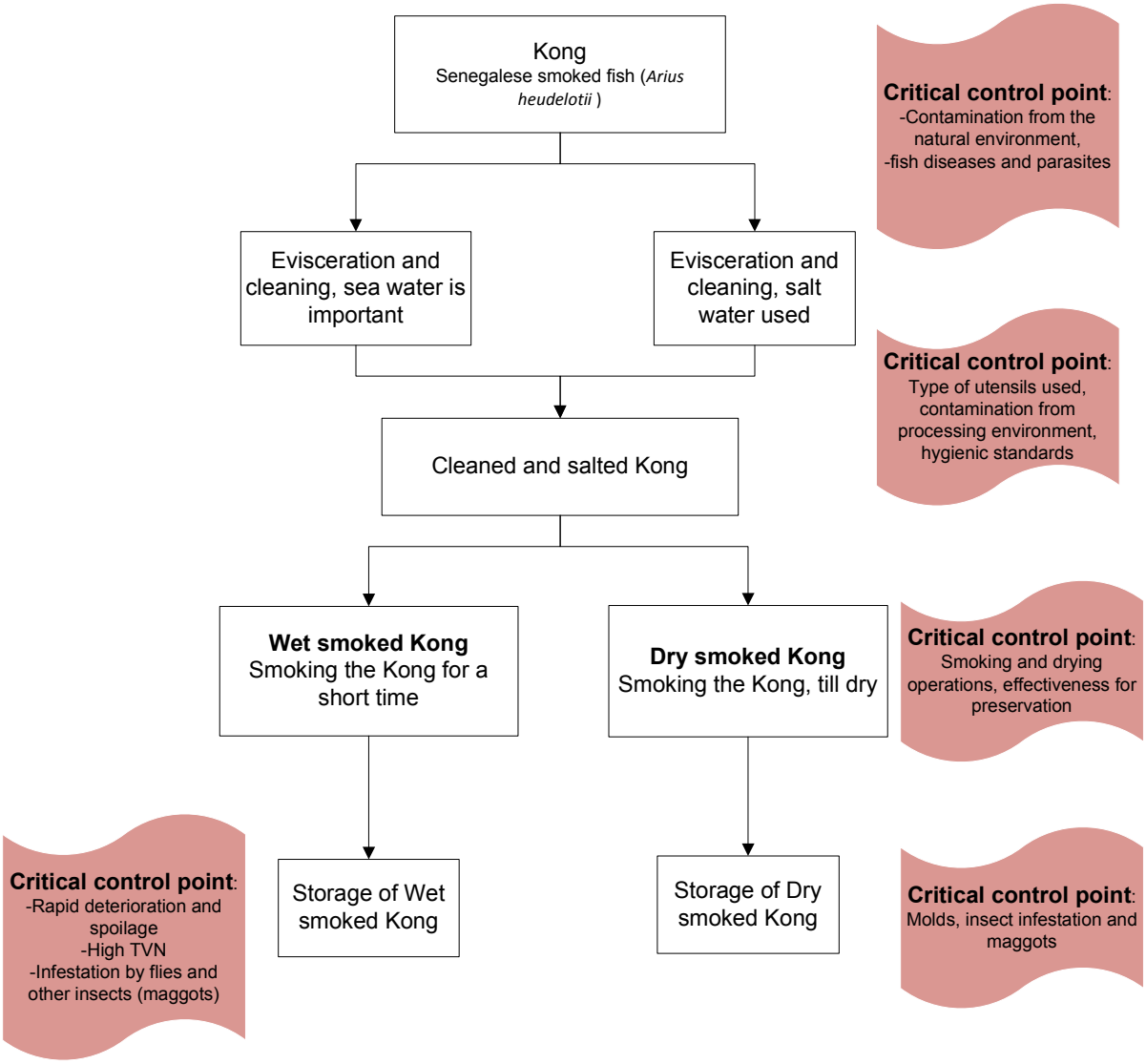

Fig 6: Flow diagram of kong processing and suggested critical control points

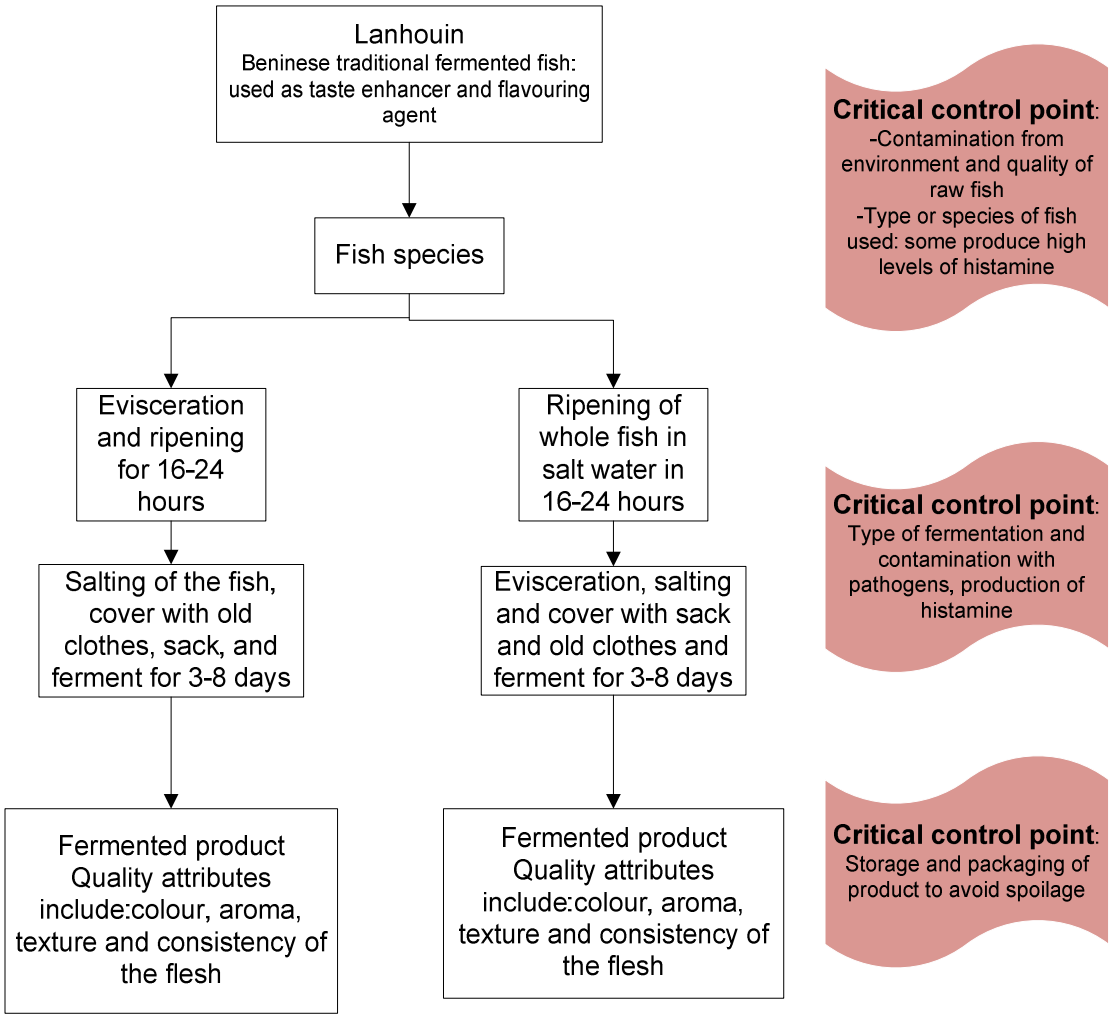

Fig 7: Flow diagram of lanhouin processing and suggested critical control points

Group 3: Plant extracts as functional foods

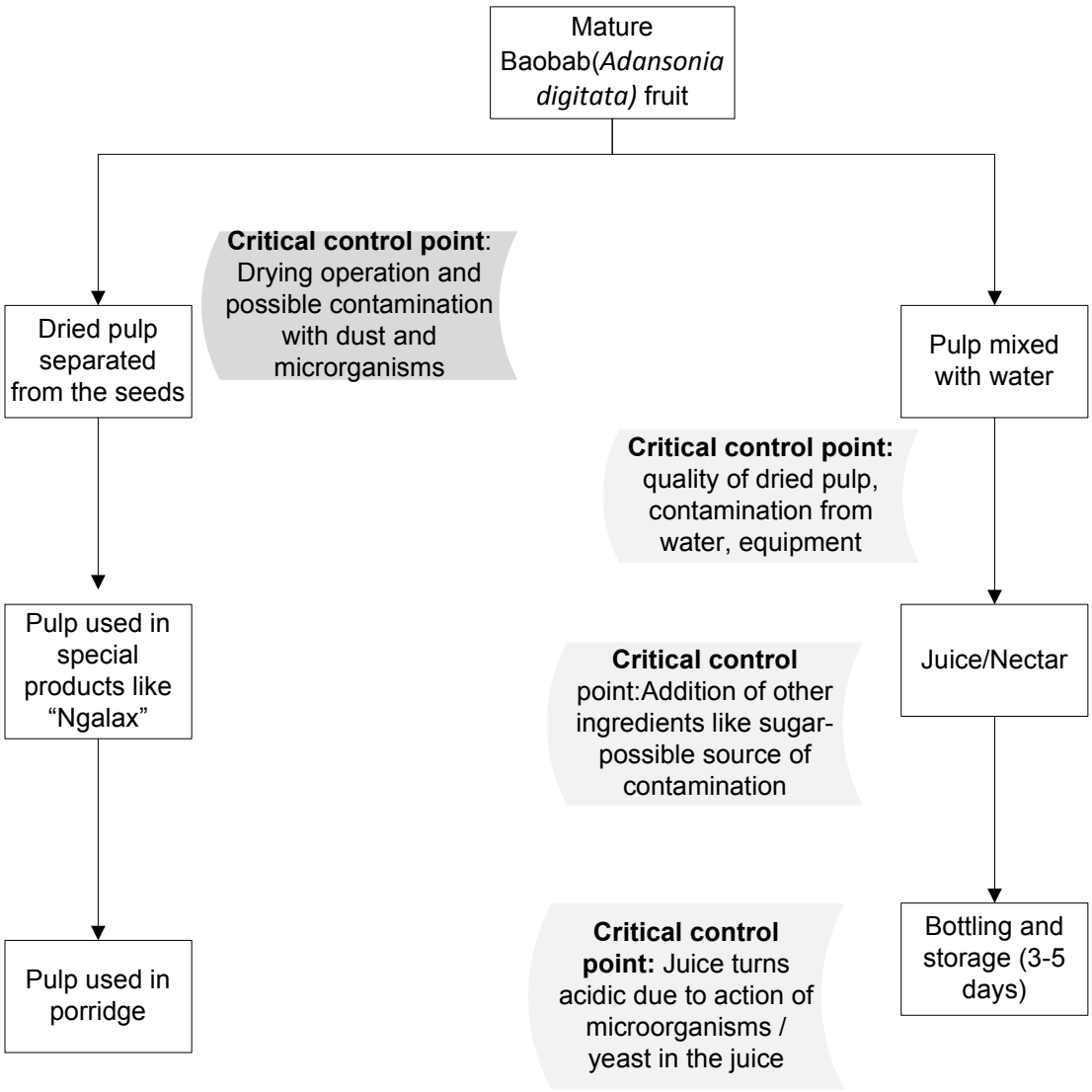

Fig 8: Flow diagram of baobab processing and suggested critical control points

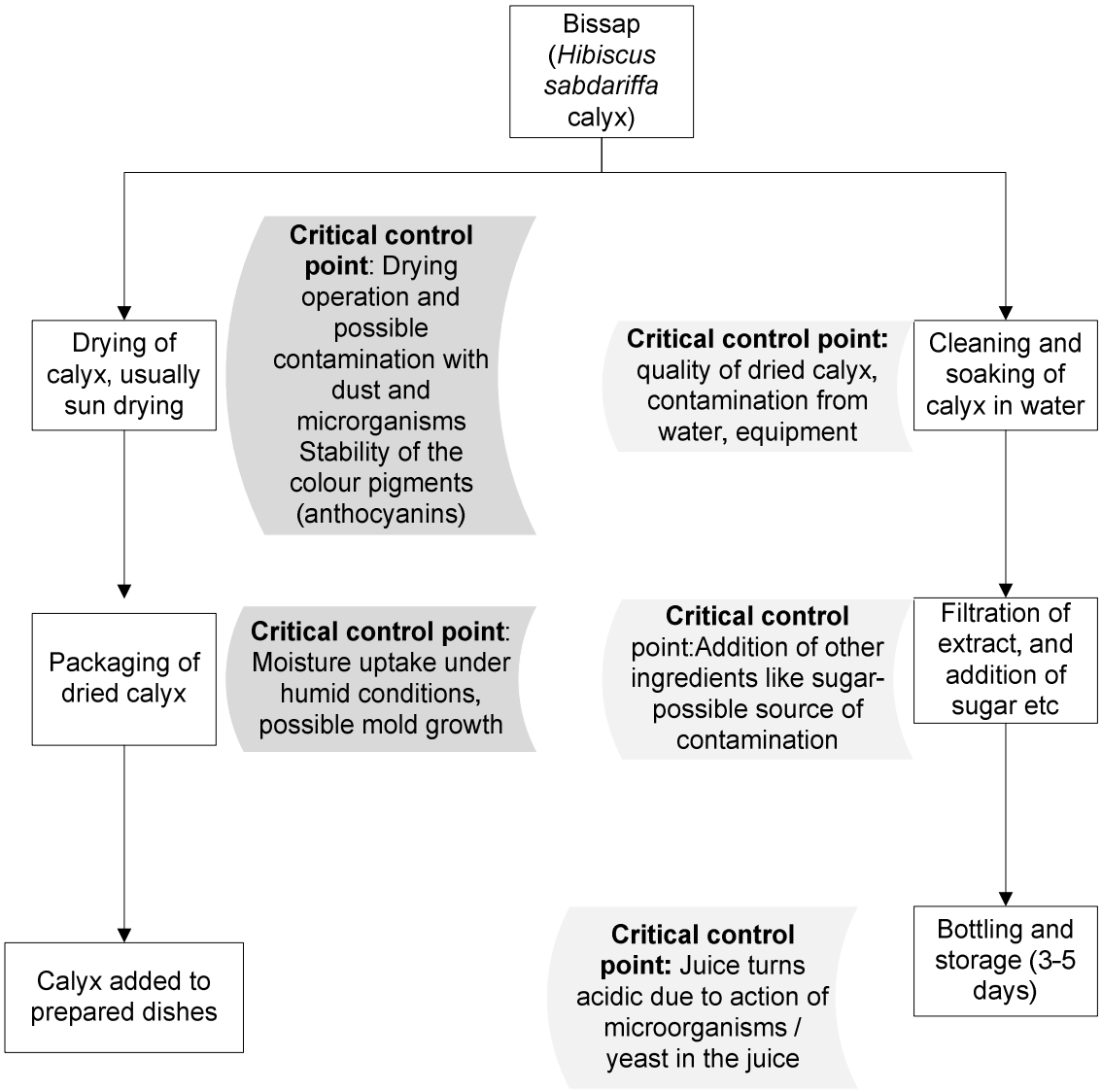

Fig 9: Flow diagram of bissap (*Hibiscus sabdariffa*) processing and suggested critical control points

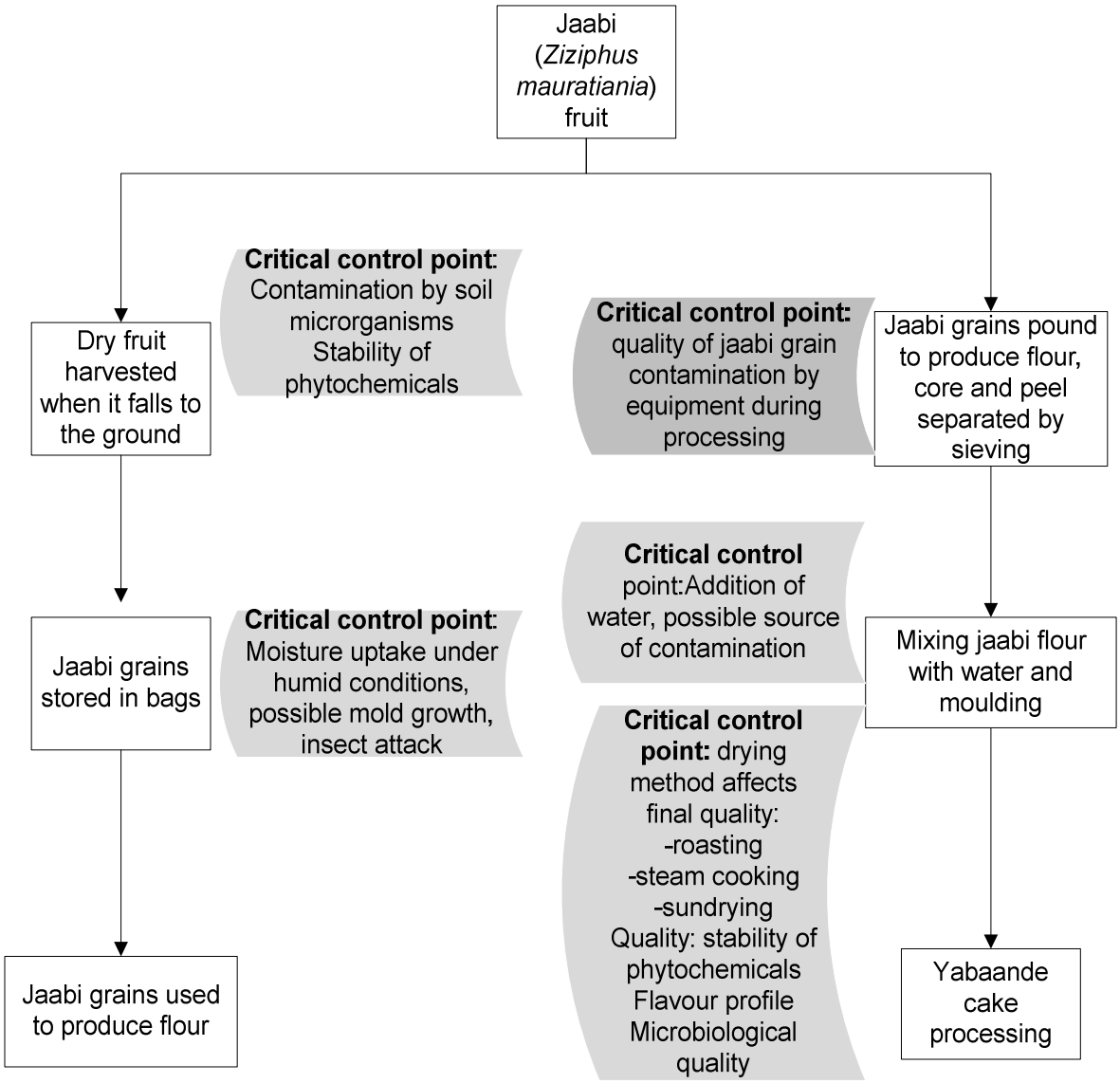

Fig 10: Flow diagram of jaabi processing and suggested critical control points

3. Critical control points

The critical control points for the products in each group almost overlap per group.

Group 1 (cereal-based products): One of the most important critical control points is the quality of the grain, followed by the steeping process, fermentation and the final quality of the products. Poor quality grain may be contaminated with mycotoxins or mycotoxigenic fungi that may contaminate the products. The fermentation steps may also result in growth of spoilage and pathogenic microorganisms if the pH does not drop to below pH 4.2 or 3.9, depending on the product. Low pH is normally inhibitory to most food spoilage and pathogenic bacteria. The level of mycotoxins can be monitored by performing laboratory tests, the best control mechanism is to reject poor quality grain, or grain with more than 13% moisture.

Group 2 (Meat and fish products): The critical control points are mainly related to the quality and sources of the fish or meat, the smoking processes and drying, as well as the final quality of the product, in terms of safety and storage. The meat or fish may be contaminated with spoilage and pathogenic microorganisms or parasites that may infect the consumer if the meat or fish is not properly processed. In some cases fish may be contaminated with environmental toxins such as the heavy metals like mercury. Thus fish may need to analysed, because, unlike microorganisms, heavy metals cannot be destroyed during processing. The fish and meat may thus be sourced from safe, reliable sources, and for meat, it is necessary for the animals to be examined and the meat certified safe for consumption by the veterinary and health departments of the country.

The smoking process also introduces the issue of the presence of benzopyrans, and the levels must be controlled by regulating the smoking process. The drying stage may introduce contamination from the dust, flies which are known to carry pathogens, and another visible problem is presence of maggots and larvae. Thus the drying process must be done in a covered environment, and flies must be repelled.

Group 3 (Plant-based plant extracts): The critical control points are mainly the raw plant material, the quality of raw materials, drying operations, pounding and packaging of dry material. The main control is on microbial and foreign material contamination, storage of dried product to avoid moisture uptake, and thus growth of moulds, that could lead to mycotoxin contamination, as well as insect infestation.

For the juices: The Quality of dried material, water used and other ingredients added, e.g. sugar, flavours may also add to critical control points to avoid contamination from these ingredients. The storage temperature (preferably low temperatures) of the juice as well as packaging and other post-

processing operations such as heat treatment and aseptic packaging may prolong the shelf life of the juices.

CONCLUSION

It is clear that an important point in all the 3 Groups is the understanding of food safety standards and hazards associated with processing, as well as the regulations. The level of education of the producers has also been highlighted by some of the surveys, with most producers being semi-illiterate, however, their knowledge in the traditional processes is very valuable, and is the reason for the current project.