African food tradition revisited by research

Project coordinator : Cirad
www.after-fp7.eu

African Food Tradition rEvisited by Research
FP7 n°245025

Start date of project: **01/09/2010**
Duration: **45 months**

Deliverable number: D1.1.1.2

Title of deliverable: Literature review and mapping

Deliverable type (Report, Prototype, Demonstration, Other): Report

Dissemination level (PU, PP, RE, CO)*: RE

Contractual date of delivery: November 2011

Actual date of delivery: January 2011

Work-package contributing to the deliverable: WP 1

Organisation name of lead contractor for this deliverable: CSIR

Authors: Adinsi, L., Akissoe, N., Vieira-Dalode, G., Hounhouigan, J., Rakotozafy, Z., Sarter S., Jeannoda, V., Rakoto, D., Kofi Amoa-Awua, W., Oduro-Yeboah, C., Halm, M., Jakobsen*, M., Ahmed, Z.S., Hassan-Wassef, H., Anihouvi, V., Kindossi, J., Ndjouenkeu, R., Biyanzi, P., Ayessou, N., Kane, C., Kebe, C.F., Cisse, M., Ndiaye, C.

This document has been send to :

The coordinator by WP Leader	Date: January 2011
To the Commission by the Coordinator	Date: October 2011

* PU: Public; PP: Restricted to other programme participants (including the Commission Services); RE: Restricted to a group specified by the consortium (including the Commission Services); CO: Confidential, only for members of the consortium (including the Commission Services)

All the literature review of the products studied in the project are included in this deliverable.

Literature review and Background information
of
Akpan

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:
Adinsi, L., Akissoe, N., Vieira-Dalode, G. and Hounhouigan, J.

Faculty of Agronomic Sciences, University of Abomey-Calavi

(Benin)

Edited by: Annali Jacobs

December 2010

Table of content

Abstract

Akpan is a yogurt-like product traditionally prepared in Benin from ogi or mawè, two fermented cereal mash products. These intermediate products are precooked and later mixed extemporally with additives such as milk, sugar and ice before consuming. As a thirst quenching beverage, it is highly valued by consumers in urban areas. Information related to socio-economic importance, traditional processing of the product, problems associated with processing and maximum duration of storage is documented through this literature review. Few research studies have been undertaken on this product and therefore the characterization of the product and its processing methods would help to upgrade and standardize its quality.

Introduction

Street foods are part of catering business in developing countries, particularly in urban areas. Most of these products are ready-to-serve or ready-to-eat foods sometimes under poor cooking and trading conditions which can lead to poor nutritive value and low hygienic quality.

A survey on traditional indigenous food processing carried out at Cotonou revealed that a large variety of foods are produced and sold by food processing micro-enterprises (Nago, 1989). Among a variety of products collected (Nago et al., 1990), traditional beverages from cereal are of high importance in the diet of Beninese. Akpan is one of these beverages derived essentially from fermented maize mash, known as « ogi », which is precooked (Adandé, 1984). It can also be obtained from mawè, another solid fermented maize mash intermediate (Nago, 1989). Akpan is prepared from essentially fermented maize starch that is precooked and then mixed with milk, sugar and ice before consumption (Mestres et al., 2001). As described by Hounhouigan (1994), akpan is a "semi-solid mass which becomes a thirst quenching beverage by adding water, ice, sugar and milk". He also reported that 7% of ogi (from maize) produced in Cotonou, are used to produce commercial akpan. Nowadays, sorghum is also used. The variability in the raw materials and processing methods used can lead to high inconsistency in the nutritional, microbiological and sensory qualities of akpan. Information on akpan is limited to the description of the product (Adandé, 1984; Nago, 1989 and Hounhouigan, 1994) and an attempt to upgrade its production process (Mestres, 2001;

Madodé et al., 2003). The later work was carried out to develop an improved process to obtain an “akpan” which could be kept for two weeks and of which the quality would be acceptable by the traditional product consumers.

To overcome major constraints related to the quality of the akpan end product and its storage shelf-life, information on traditional processing of the product, problems associated with processing and maximum duration of storage, as well as quality profiles are needed. This review intends to collate data on each of these aspects.

1. Traditional processing of the product

1.1. Raw materials and additives used and their handling

Akpan is traditionally prepared from maize, but no specific variety is preferred. However, no waxy variety would be appreciated. No report on the use of other cereals has been found and this aspect needs to be investigated. The maize is sorted and cleaned in order to discard the rotten grain and the foreign matter. In practice, the raw materials are the intermediates: precooked fermented maize mash (ogi) or solid fermented maize mash (mawè) described by Hounhouigan et al. (1994). Ogi is a gruel obtained by fermentation of a suspension of wet-milled maize in water, while mawè is a fermented maize dough, rolled up into a ball and sold at local markets as opposed to ogi which is not marketed in this state.

During processing of ogi into akpan, no additives are used. Additive-like ingredients are only used during consumption. These include milk, sugar and ice or the sour ogi supernatant is sometimes used.

1.2. Description and variability/similarity of processing methods

The traditional process of akpan production can be devised into two main steps: the preparation of intermediate products (ogi or mawè) and the processing of ogi into akpan specifically. According to Nago (1997) the general procedure of processing of ogi includes steeping of grain, wet-milling, wet-sieving, decanting and fermentation. Similar products are processed in many other African counties such as “akamu” in Nigeria (Akingbala et al., 1987), “uji” in Kenya, “mahewu” in South Africa (Steinkraus, 1983) or poto poto in Congo (Brauman et al., 1993). Some slight variations may exist from one country to another: steeping is performed at ambient temperature for 2-3 days in Nigeria (Akingbala et al., 1987) while this operation is done by boiling for a few minutes and then steeping for less than 2 days in Benin (Nago et al., 1998) (figure 1).

During grain steeping, and moreover during decantation and souring of the slurry, an hetero-lactic fermentation proceeds, involving specific microorganisms and a pH around 4 (Banigo & Muller, 1972)

As far as mawè is concerned, the processing methods were further described by Hounhouigan (1994) (figure 2). A similar product also known as mawè was described by Doh (1970) in Togo. According to Nago et al. *(*1993), the pH ranged between 3.5 and 4 and water content between 45-49%.

With respect to akpan, Adande (1984) earlier described the origin, preparation and consumption as follows : « *Akpan (Goun)- Dans les marchés de la région de Porto-Novo notamment, on se désaltère dans le secteur des marchandises d'Akpan ou Akpan soji. Akpan n'est autre chose que l'Akassa préparé avec davantage d'eau retirée de la fermentation du maïs. Il est par conséquent d'un goût très acidulé et ne s'accommode jamais de la sauce. Sa consistance est moindre que celle de l'Akassa.*

A l'acheteur, la vendeuse se charge de la délayer elle-même dans une calebasse d'eau potable et fraîche pour en atténuer l'âcreté et lui rendre une saveur aigrelette légèrement sucrée. Cette boisson étanche agréablement la soif. Elle est connue dans la région d'Abomey sous l'appellation de Tongi (bouillie sucrée et aigrelette.) »

Mestres et al. (2001) developed an improved procedure of production of akpan from the ogi. Akpan is prepared by mixing cooked and non-cooked ogi slurry (figure 3). The resulting product "akpan" is extemporally mixed with additives before consuming.

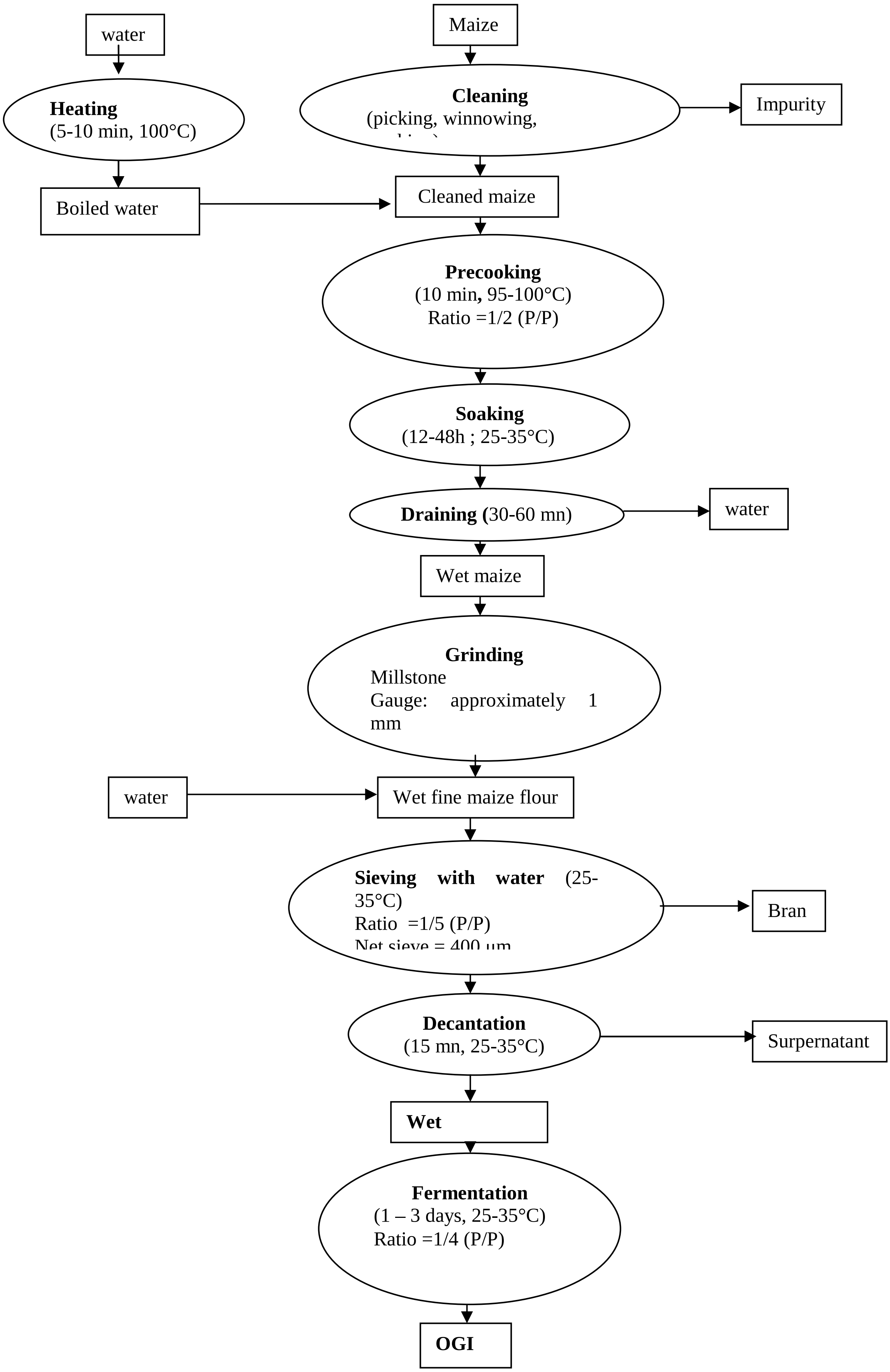


Fig.1 : Diagram of the production of traditional ogi in Benin (Nago, 1997)

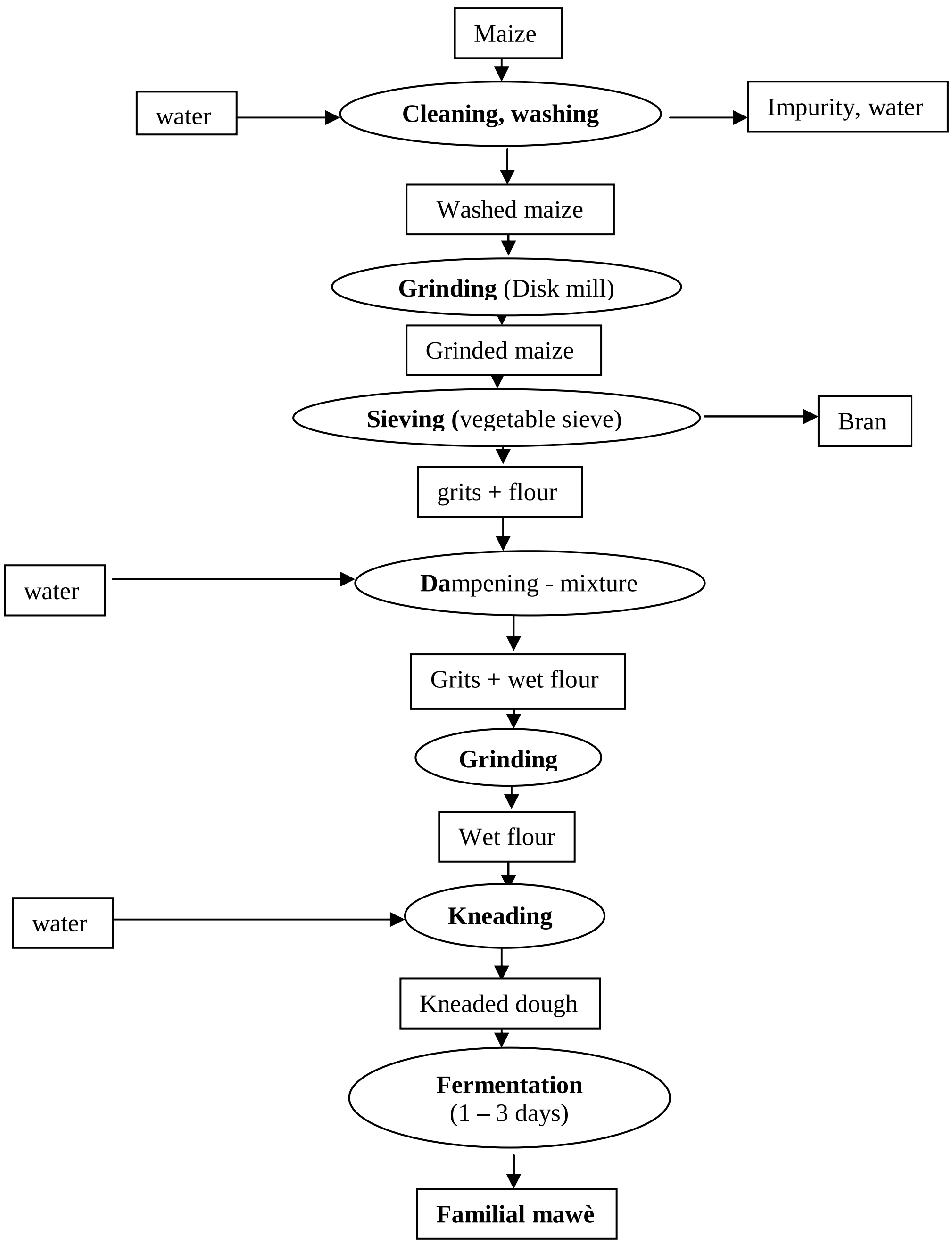


Fig.2: Diagram of production of familial mawè in Benin (Hounhouigan et al., 1993)

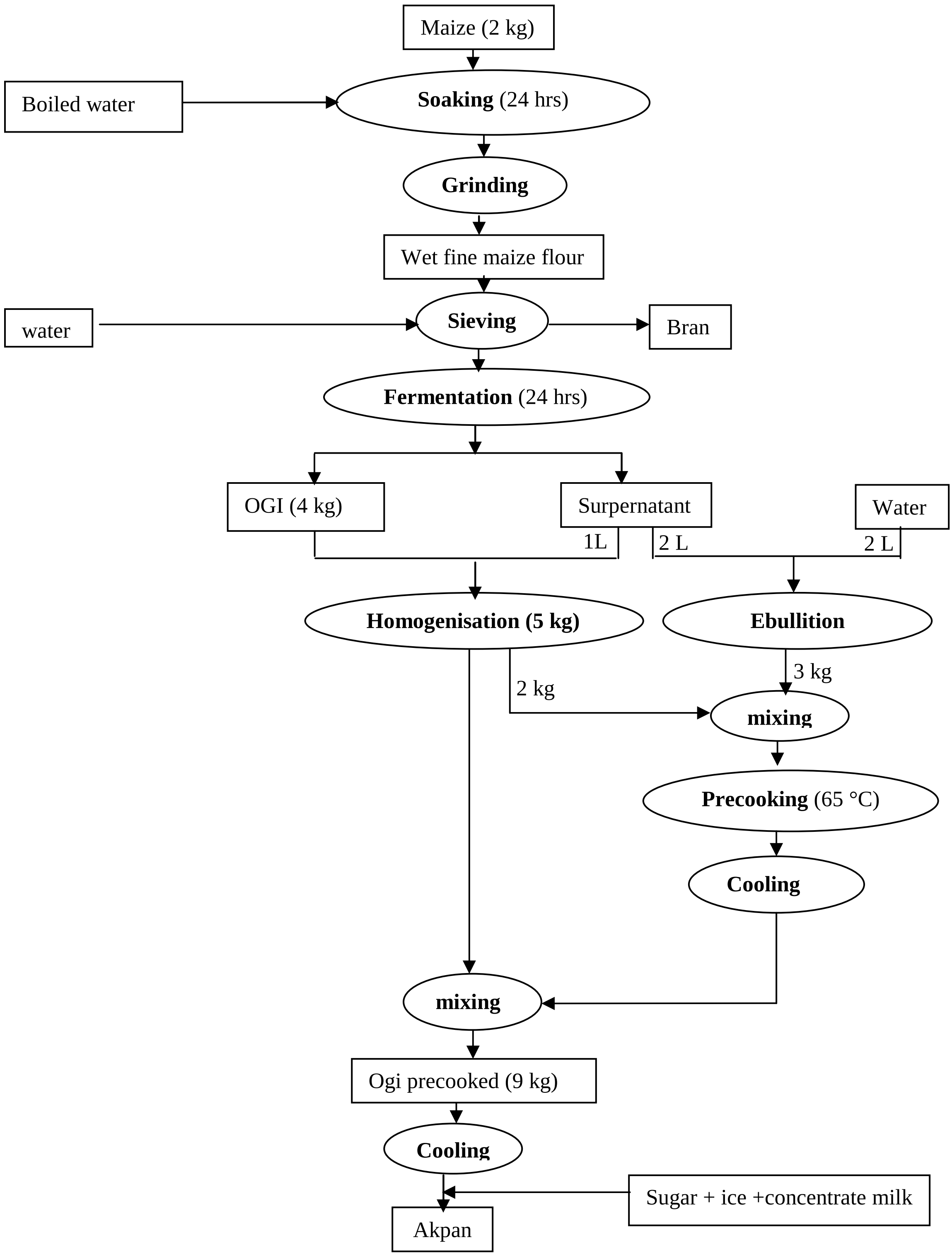


Fig.3: Diagram of traditional production of Akpan (Mestres et al., 2001)

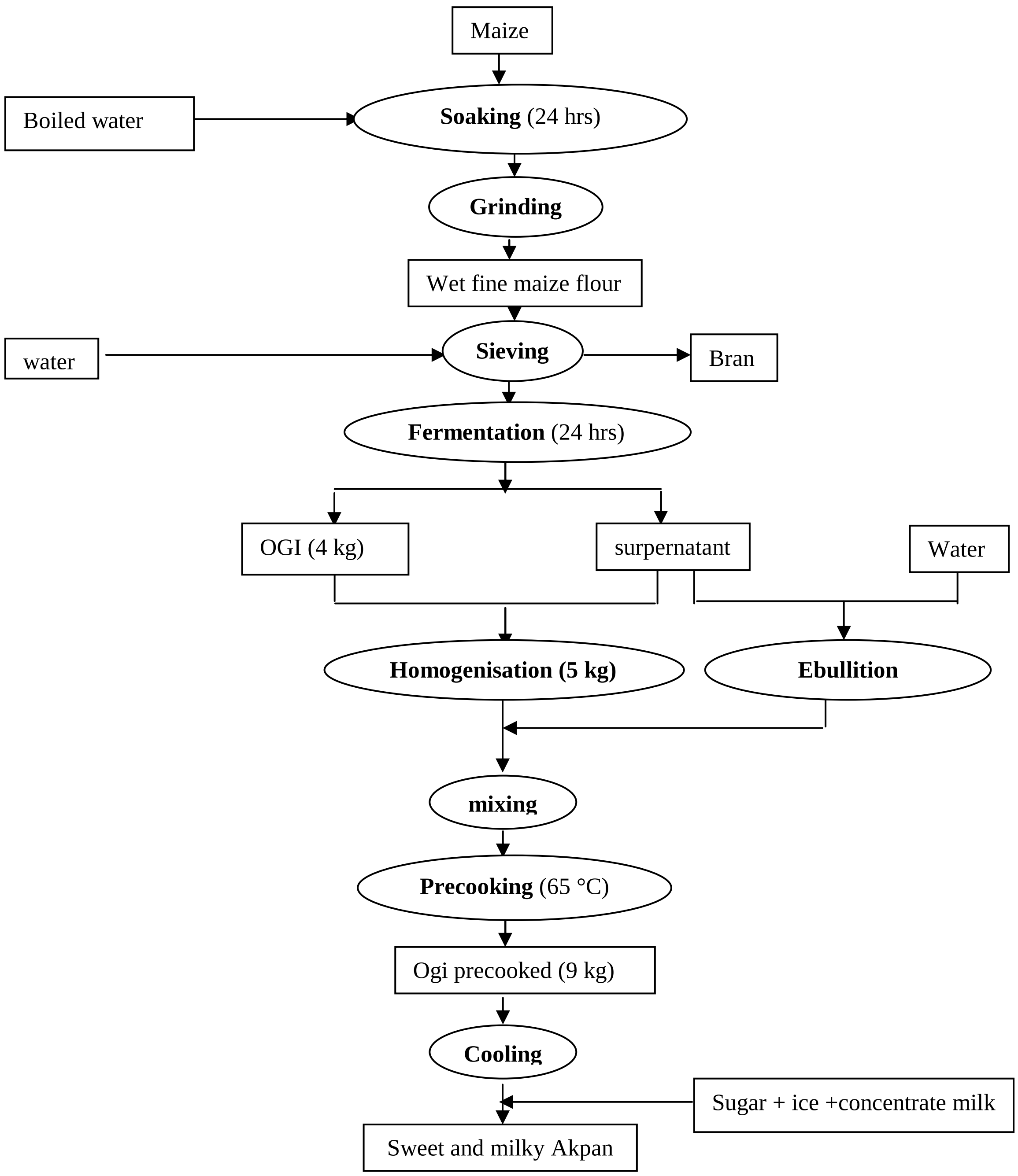


Fig. 4: Diagram of the improved production of Akpan (Mestres et al., 2001)

1.3. Major problems associated with processing method

Contrary to ogi which has been widely investigated, the microbiological profile and biochemical characteristics of akpan are still largely unknown. The most important constraint of the process is the lack of standardization of all the unit operations, especially of the fermentation and cooking operations. The intermediate products (ogi or mawè) and the akpan itself become sour during storage/marketing. Consequently, the shelf life of akpan is too short. In addition, the sensory profile and quality attributes are not well-known. The processing method from cereal grain to end product is time-consuming; so the need for stabilization of intermediate products like ogi or mawè as powder/flour can be beneficial to the processors.

.

1.4. Storage methods, maximum duration and problems associated with storage

In traditional practice, akpan is kept at ambient temperature (24-30 °C) for several days. It can be rolled up into balls and packed in leafy vegetables for selling. Generally, akpan is a ready-to-serve product with a shelf-life of about 2 days. However, akpan can be kept for up to 8 days at 4 °C (Madodé, 2003). As a fermented wet product, akpan becomes too sour during storage, leading to deterioration in quality. Further research is therefore needed to ensure the quality of the product.

2. Socio-economic importance

2.1. Production, processing, handling and storage zone identified in the country

A preliminary study revealed that akpan originates from Porto-Novo (Adande, 1984), probably in relation with ogi production. Indeed, ogi is mainly produced in this region. Currently, akpan is processed mainly in the southern areas (Oueme, Atlantic, Littoral and Zou) of Benin. However, increased production of akpan in the northern urban regions was observed recently, probably originating from the south of the country.

2.2. Socio-economic profile of the actors

In the usual practice, the production and the commercialization of akpan is undertaken by the women. For the distribution of the product, two types of sellers were observed:

- **fixed sellers** for ready-to serve and for ready-to-eat and
- **train buffet trolley**/snack trolley women.

Little information currently exists on the profile of the actors in this sector and therefore a further survey is needed to collect information related to this aspect.

Socio-economic importance of the product

Akpan is produced at home, without any manufacturing but with small scale enterprises. As a street food, akpan is consumed throughout the day and the year. It is preferably consumed as a thirst quenching beverage during hot weather. Hounhouigan (1994) revealed that 7% of maize used to produce ogi in Cotonou was consumed as akpan. According to Nago (1989), with 4750F CFA (10$US) as initial production cost, processors can get 2050 F CFA (4.3$US) as net income (43%). A survey of the current costs and economic impact is necessary.

2.3. Commercialization of the product

Akpan is a street food widely consumed in towns. “Ready-to-eat akpan” is served in a cup containing about 14 to 27.5 cL of which the cost varies between 75 – 100 CFA (Mestres et al., 2001). The cost is about 3 times lower than the price of similar commercially manufactured drink like yoghurt. Akpan is extemporally mixed with sugar, ice, concentrated milk in variable proportions before consuming. In addition, people sometimes add the sour surpernatant obtained during ogi production. As far as “ready-to serve akpan” is concerned, it is packed in leaves and sold in this state. It is consumed at home after reconstitution. For snack trolley women, akpan is sold as a “ready-to-drink beverage”.

3. Quality characteristics of the product

3.1. Nutritional quality

Initially akpan without additives should have approximately the same nutritional quality as ogi. When adding additives, the nutritional quality of akpan would change but, up to date, no research has been performed to collect this information which constitutes a large research gap.

3.2. Microbiological quality

Numerous studies were done on the microbiological profile of ogi, but little research has been undertaken on akpan. The absence of enterobacteria (mainly the coliforms) in the product was noted. The mean load of aerobic mesophilic organisms and yeasts and moulds are 4.98 Log (CFU.g^{-1}) and 5.28 Log (CFU.g^{-1}) respectively.

3.3. Physico-chemical and sensory characteristics

Very little data exist on the physico-chemical quality of the akpan. Previous studies are only limited to the pH, titratable acidity and apparent viscosity. Table 1 shows mean values obtained by Mestres et al., (2001). Further research is needed to identify dextrin profiles and aroma components. In addition, data on particles size and degree of gelatinization are needed.

As far as sensory quality is concerned, akpan has a sour taste (slightly acid), but it is sugary when consumed with additives. It is also described as a flavored product, sometimes with an alcohol smell.

Table 1: Physico-chemical characteristics of Akpan

Parameters	Values
pH	4,41
Titabl acidity (% of lactic acid dm)	1,5
Viscosity apparent (cP)	441

Source: Mestres et al., (2001)

3.4. Product quality perception/requirement by consumers

Madodé et al. (2003) reported that a good akpan must be slightly acid/sour, with white color. It must be slightly viscous and fairly cooked. He noted also a divergence of viewpoint on the taste attributes “sugary’ and ‘milky’ even though the majority of consumers interviewed prefer a fairly sugary and milky akpan.

4. Consumption forms of the product

4.1. Food forms

Akpan is consumed as milky, sugary and chilled drink with a viscous and watered texture. It is known as thirst quenching beverage.

4.2. Period of the day for the consumption

The survey done by Madodé et al., (2003) revealed that akpan is consumed mainly after lunch. It is also consumed as snack at mid-afternoon around 17h00. However, consumption is not limited to these times and one can consume akpan during any period of the day.

5. Research activities and new development on technology and product

Research studies on akpan are very limited; so, further studies should focus on the nutritional, microbiological and sensorial quality of the product. In addition, the flow diagram and product quality must be upgraded. Data on socio-economic aspects must be updated with recent information. The following studies could be performed:

- Physico-chemical characteristics, microbiological profile and sensory profile of akpan
- Control of the fermentation of the ogi by the use of a starter culture
- Standardization of cooking by modeling the process
- Improvement of the shelf-life of the product

Conclusion

Akpan is a beverage derived from fermented maize/sorghum, often consumed especially in the urban zones of Benin. This product is consumed mainly after the lunch and secondarily as snack at mid-afternoon. It is thirst quenching beverage and, after reconstituting, it tastes slightly sour, sugary and milky, and fully-flavored. The shelf-life of akpan is limited (around 2 days), even if attempts have been made to maintain the quality up to 8 days at 4 °C. Little is known on the nutritional value, physico-chemical and microbiological characteristics of akpan . Updated socio-economic data also need to be provided.

References

Adande, S. A. 1984. Le maïs et ses usages au Bénin méridional, Agence de coopération culturelle et technique, Les Nouvelles Editions Africaines, 100p.

Akingbala, J. O., E. U., Onochie, et al. ? 1987. "Steeping of whole and dry milled maize kernels in ogi preparation." *Journal of Food Processing and Preservation*. 1(11): 1-11

Banigo, E. O. & Muller, H. G. 1972. "Manufacture of ogi (a Nigerian fermented cereal porridge): Comparative evaluation of corn , sorghum and millet." *Canadian Institute of Food Science and Technology Journal*. 5(4): 217-221

Brauman, A., L. Thystere, et al.? 1993. "Un exemple de biotechnologie à l'échelle artisanale: La fermentation de la pâte de maïs." Congo Actualités. 6: 10-11.

Doh, J.A. 1970. Le maïs dans l'alimentation ouest-africaine. Bilan protéique de sa transformation en certains aliments fermentés. Thèse, Université de Dijon, France, pp. 33-39

Hounhouigan, D.J., Nout, M.J.R., Nago, C.M., Houben, J.H., and Rombouts, F.M. 1993. Composition and microbiological and physical attributes of mawè, a fermented maize dough from Benin. Int. J. Food Sci. Technol., 28, 513-517

Hounhouigan, D. J. 1994. Fermentation of maize (*Zea mays* L.) meal for mawe production in Bénin. Physical, chemical and microbiological aspects. Wageningen ?: 99 p.

Madodé ?. 2003. Valorisation des technologies de transformation de produits vivriers : Test de production et de marché pour le « Akpan » une boisson fermentée à base de maïs. ??

Mestres, C., Bada-Ogoun, M.C., Michodjèhoun, L. & Hounhouigan, J. 2001. Compte rendu d'étude sur la « valorisation des produits vivriers du Bénin » CIRAD-CERNA 27p.

Nago, C.M.? 1989. Technologies traditionnelles et alimentation au Bénin : aspects économiques, biochimiques et nutritionnels. Identification et identification des principales filières et technologies traditionnelles de transformation de produits alimentaires. Rapport d'étude, Abomey-Calavi, Bénin, FSA/UNB 222p.

Nago, C.M.,Devautour, H. and Muchnik, J. 1990. Technical resources of food processing nicro-enterprises in Benin, Agritrop, 14, 3, 7-11

Nago, C.M., Thuillier, C. & Hounhouigan, J. 1993. Etude des systèmes techniques de transformation artisanale du maïs au Bénin. Actes de journée scientifiques du CIRAD, Montpellier, Novembre 1992, pp 385-404.

Nago, C.M. 1997. Transformation alimentaire du maïs au Bénin : Détermination des caractéristiques physico-chimiques des variétés en usage ; relation avec l'obtention et la qualité des principaux produits dérivés. Thès. Doc. es-Sci, UFR Bioch, Univ. Paris 7, 571p.

Nago C. M. ; Hounhouigan D. J. ; Akissoé N. ; Zanou E. and Mestres C. 1998 : Characterization of the Beninese traditional ogi, a fermented maize gruel : physico-chemical and microbiological aspects. International Journal of Food Science and Technology, 33 : (3) - 307

Steinkraus, K. H. 1983. Indigenous fermented foods involving an acid fermentation. Handbook of indigenous fermented foods. K. H. Steinkraus. Ed? New-York, Microbiology series: 95-299.

Literature review and Background information

of

Bissap

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:

Cisse, M.

Ecole supérieure polytechnique de Dakar
Université Cheikh Anta Diop de Dakar

Edited by: Annali Jacobs, Joseph D. Hounhouigan

December 2010

Table of contents

Abstract

Production area. Introduced in the country in the XIXth century, *Hibiscus sabdariffa* L. is grown throughout the territory of Senegal, particularly in the Kaolack, Djourbel, Thies, Saint-Louis and Louga regions.

Varieties. Several varieties of red *H. sabdariffa* calyx are cultivated in Senegal. Four main varieties namely Vimto, Koor, CLT 92 and Thai can be distinguished. It appears that there are no appropriate structures for the shelling, drying, packaging and storage for the calyx of *H. sabdariffa*. These operations are performed under unsuitable conditions leading to the deterioration of the quality of the *H. sabdariffa* calyx.

Composition. The red calyxes are the most commonly used and are characterised by their concentration of anthocyanin, which can reach 1.5 $g.kg^{-1}$ of dry matter. Delphinidin 3-sambubioside and cyanidin 3-sambubioside are the major anthocyanins comprising 70 and 29 % of total anthocyanins respectively. Organic acids, minerals and amino acids are present in the calyx,

Transformation. The main processing activities of the *H. sabdariffa* calyx are crushing and the production of drinks and concentrate. The manufacture of beverages, the main method of transformation, carried out under the direction of women's groups, has remained virtually traditionnal.

Markets. With a support program of the Senegalese state, the increase in the cultivated areas and the number of actors, *H. sabdariffa* occupies an important place in the marketing of agricultural products in Senegal. The export of dried calyx of *H. sabdariffa* to Europe and the United States at prices ranging between 1,000 and 2,500 $\$US.t^{-1}$ is increasing year by year.

Introduction

Hibiscus sabdariffa L. is a herbaceous plant, cultivated largely in tropical and subtropical areas of both hemispheres. It belongs to the family of Malvaceae and is known by different names such as Guinea sorrel or bissap in Senegal, karkadé in North Africa, roselle or sorrel in Asia and flora of Jamaica in Central America (Morton & Roselle, 1987; Glew et al., 1997; Lorenzo et al., 2000 ; McClintock.& El Tahir, 2004 ; Babalola et al., 2001 ; Nyarko et al., 2006 ; Cisse et al., 2009a; Cisse et al., 2009b)

In Senegal, *H. sabdariffa* was introduced in the 19th century (Kerharo & Adam, 1974) and is now grown throughout the territory; mainly in the Kaolack, Diourbel, Thies, Saint-Louis and Louga regions (**Figure 1**). In these areas, a dozen varieties are grown including Vimto, Koor, Thai and CLT 92. Indeed, with the decline of traditional crops, especially peanut, many producers are now growing bissap to improve their income.

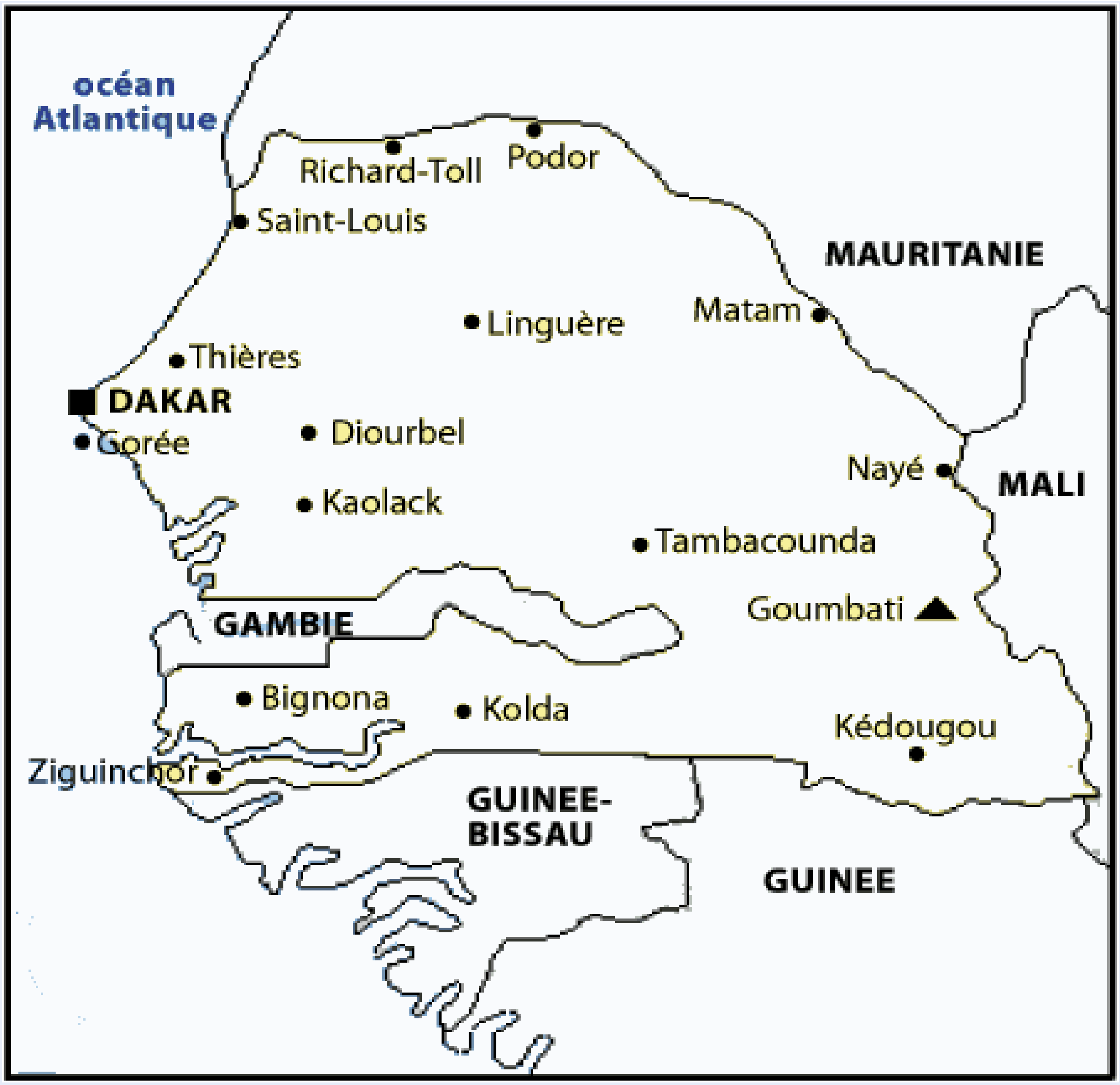


Figure 1. Main areas of *Hibiscus sabdariffa* cultivation

1. Traditional processing of the product

In Senegal, traditional processing of the *H. sabdariffa* calyx has been greatly improved by the establishment of many small enterprises.

1.1. Raw materials and additives used and their handling

H. sabdariffa is cultivated mainly for its calyx. The traditional processing activities of the calyx are for the production of jam, concentrates and particularly of drinks/beverages.

The drink is made from an extract obtained by aqueous extraction from a solid-to-solvent ratio. The extraction operation is carried out at temperatures between 25 and 100°C. After filtration, sugar and other ingredients, such as other fruit juices, flavorants and fruit pieces (pineapple, strawberry and ginger) may be added.

The consumption of this drink is widespread in Africa and Asia. In Senegal, where it is very popular, its consumption is highest during the month of Ramadan. In Mali, Côte d'Ivoire and Burkina Faso, the drink is called “da Bilenni”. In Egypt, it is known as the "drink of the Pharaohs." In Sudan the name is "tea Karkade”. This beverage is consumed cold or hot , depending on the season.

1.2. Description and variability/similarity of processing methods

The description and processing methods used for *H. sabdariffa* calyx in Senegal are represented in **Figure 2**. Variability is closely related to similarity between producers (Cissé et al. 2009a)

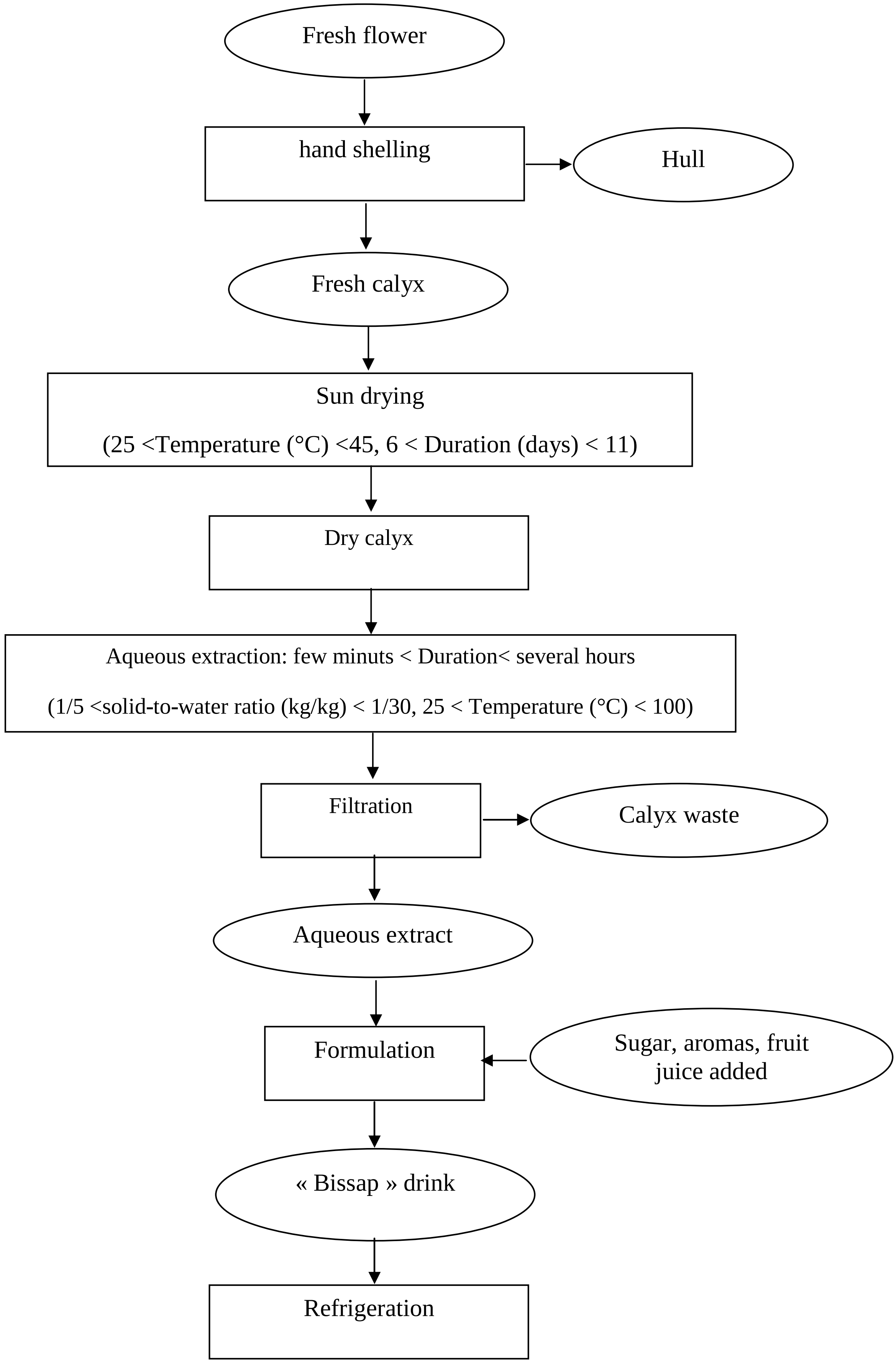


Figure 2: Flow diagram of traditional processing of *Hibiscus sabdariffa* drink in Senegal

1.3. Major problems associated with processing methods

The operations of shelling and drying are carried out manually. These operations lead to a raw material of heterogeneous quality.

During the production of *H. sabdariffa* drink, the main problem is the lack of adequate technical resources. The women rely on their knowhow and experience to determine the end of each step. This could result in a heterogeneous production process and in medium or poor quality beverages.

1.4. Storage methods, maximum duration and problems associated with storage

According to producers and traders, the red color of calyx turns brown or black after 3 months of storage. In fact, there are no appropriate structures for the shelling, drying, packaging and storage for the calyx of *H. sabdariffa*.

After production, the drinks are stored in plastic bottles at 4 °C for 4-10 days. Usually no treatment is applied to stabilise the finished product. More significant degradation of anthocyanins has been noted during heat treatment (Cisse et al., 2009).

2. Socio-economic importance

2.1. Production, processing, handling and storage zones identified in the country

2.1.1. Production

In Senegal, the cultivation of *H. sabdariffa* is an ancient activity, usually conducted by extensive farming in the Kaolack, Diourbel, Thies, Louga and Saint Louis regions (**Figure 1**).

In the northern regions of Louga and Saint-Louis, Hibiscus is cultivated mainly in lines on the boundaries of rice plots. In these regions Hibiscus is cultivated also in association with millet, maize and groundnuts crops.
In the central regions of Kaolack and Diourbel, *H. sabdariffa* is grown mainly in association with groundnut or millet. However, monoculture of *H. sabdariffa* is becoming more and more frequent because of the exports opportunities of the dried calyx..

The increase of *H. sabdariffa* cultivation is encouraged by the support of non-governmental organizations such as ASNAPP (Agribusiness in Sustainable Natural African Plant Products). The Hibiscus was selected from twelve products as a minor crop in Senegal, but with great potential to improve the income for producers.

2.1.2. Postharvest treatment

After harvesting, dried calyx of *H. sabdariffa* undergoes the steps of shelling, drying, packaging and storage.

Decortication

Scouring is a delicate manual operation, and requires a skilled workforce. It involves taking the fruit between two hands and then making a vertical incision with both thumbs to separate the capsule and calyx (**Photo n°1**). It is often difficult and painful because of the pressure required to separate the calyx and capsule and for some varieties, the presence of irritating stinging hairs.

Photo n°1. Manual scouring of *Hibiscus sabdariffa*

Some operators cut the base of the flower stalk with a knife to release the capsule and get a circular closed calyx. This method can damage the capsule which then opens slightly and releases the seeds. Significant losses are incurred by breaking the sepals with a knife. To reduce these losses some farmers dissect the flowers only 24 hours after harvest. A real need for mechanization of this step is obvious. It constitutes a major obstacle to the development of the *H. sabdariffa* industry.

Drying

Drying is carried out after shelling. It reduces the moisture content of the calyx from 86% to 16% or 14% for improved preservation. Currently drying is traditionally performed by direct exposure of the calyx to the sun. Calyxes are spread on mats or plastic sheets placed directly on the ground.

This method has major disadvantages, such as the important risk of microbiological contamination, presence of sand and debris, anthocyanins degradation, losses of nutritional compounds. The duration of drying is between 6 and 10 days.

Studies on drying kinetics and the impact on the quality of calyx should be envisaged to better control this step.

Packaging

The dried calyxes are harvested and sold in bulk or in individual packages. For export, dried calyxes are baled in batches of 50 kg in woven polypropylene bags. Packaging dried calyx in polypropylene bags is the most widely used because of the good ventilation allowed by this type of packaging and the low cost. The price per bag varies between 50 and 100 FCFA (0.08 and 0.15 euro). This conditioning is used both by producers and collectors.

Transport and storage

Transportation of dried calyx of *H. sabdariffa* between production areas and urban centers is performed by truck with a capacity from 15 to 30 t. *H. sabdariffa* can be transported at the same time as other crops such as groundnuts, millet and corn. The price depends on distance and is between 10 and 20 $CFA.kg^{-1}$ (0.015-0.03 euro). We have noted the lack of appropriate structures for the storage of dried packaged calyx.

The packaged products or bulk products are stored outdoors or under cover in major urban markets or in a facility where other products are stored. The storage time varies and depends on the consumption or marketing. The calyx can be kept until the next harvest. However, according to producers and traders, the red color of calyx turns brown or black after 3 months of storage.

In conclusion, it appears that there are no appropriate structures for the shelling, drying, packaging and storage for the calyx of *H. sabdariffa*. These operations are performed under unsuitable conditions which lead to the deterioration in the quality of *H. sabdariffa* calyx.

2.2. Socio-economic profile of the actors

Producers of *H. sabdariffa* can be divided into two main groups. The first one represents about 70% of producers and consists of traditional producers who grow Hibiscus around crop fields. The other emerging group, about 30% of producers, consists of women's groups and economic interest groups cultivating plots of Hibiscus on areas ranging from 1 to 5 ha in size.

Processors of *H. sabdariffa* in Senegal can be divided into two groups: small-scale processors and industrial transformers. The small-scale processors do not have adequate technical capacity.

Many large industrial Senegalese companies have investigated the transformation of *H. sabdariffa* calyx, but up to now, only two companies, Kirene and Laiterie du berger, offer drinks made from *H. sabdariffa* calyx. Two main constraints have been identified: inhomogeneity of the raw material and problems of discoloration of the beverage over time.

2.3.Socio-economic importance of the product

With an average acreage between 5000 and 6500 ha for a domestic production of 1200 to 3000 t (per year) and an estimated 30 000 to 40 000 producers, *H. sabdariffa* currently holds an important place in the marketing of agricultural products in Senegal. (Cisse et al., 2009a). Crops of *H. sabdariffa* provide substantial income to producers. The marketing of calyx is provided by producers, street vendors and wholesalers established most often at urban markets. These wholesalers supply exporters of dried calyx. The price offered to growers varies between 750 and 1000 F CFA (1.14 – 1.53 euros) per kg of calyx.?.

2.4. Commercialisation of the product

National market requirements for calyx for household and artisanal processing are estimated to be 700 t (per year). In Senegal, in most cases, the *H. sabdariffa* calyxes are sold in two units of measurement: a basin corresponding to a capacity of 5 kg and a tin with a capacity of 250 g. The price of dried calyx varies by location of sale and time of year. Thus, in the weekly markets, the sale price of the basin ranged from 2000 FCFA in October (beginning of harvesting) to 5000 FCFA for the month of May; either 400 to 1000 FCFA. kg^{-1} of calyx. The price of a tin generally varies from 125 to 175 FCFA and 500 to 700 FCFA.kg^{-1} over the same period. On national roads and in the large urban areas, prices charged are usually higher than those observed at the weekly markets.

Exports of *H. sabdariffa* calyx are mainly to the United States and Europe, including, notably France and Germany (Anonym, 2000; Gueye, 2005) , which constitutes 80% of the European market which is estimated at 3000 t/year. Calyxes are exported for the food and cosmetics industry. Very little data is available on export quantities. Limited data is available at the computer center of the Senegalese customs which reported export quantities of 923 and 312 t in 2000 and 2001 respectively. Highest annual exports were recorded in 2003 and 2004 with respective quantities around of 1000 and 1400 t.

The quantities currently exported are far from satisfying international demand. Indeed, with agreements of the African Growth and Opportunity Act (AGOA), the needs of the American market are estimated at 30 000 t/year. The prices on the world market show large fluctuations. The average market price is between 1000 and 2500 U.S. $\$.t^{-1}$. These prices obviously depend on the quality of the product which is judged primarily on the variety of Hibiscus, varietal purity and rate of whole calyx (Cisse et al., 2009a).

3. Quality characteristics of the product

3.1. Nutritional quality

The composition of *H. sabdariffa* calyx is highly variable (**Table 1**).

Table 1. Minimum ,maximum and average values, of the different characteristics of *Hibiscus sabdariffa* calyx (Kerharo & Adam, 1974; Morton & Roselle, 1987; Wong et al., 2002; D'Heureux–Calix & Badrie, 2004; Cisse et al., 2009b)

	Units	Minimum	Average	Maximum
Moisture	$g.100g^{-1}$	84.5	86.3 (8)	89.5
Protein		0.9	6.6 (8)	17.9
Lipid		0.1	2.3 (7)	3.9
Fibers		2.5	8.8 (6)	12.0
Ash		4.5	5.6 (5)	6.8
Carbohydrates		3.3	8.1 (4)	12.3
Malic acid		0.12	1.36 (3)	2.70
Calcium	$mg.100g^{-1}$	1.3	94.0 (9)	213.0
Iron		2.9	17.2 (9)	37.8
Phosphorus		40.0	191.1 (6)	312.6

Ascorbic acid	6.7	72.0 (6)	141.1
Anthocyanin	150	350 (5)	1500

() Number of values taken into account in calculating the average

Except for moisture and fat, differences between the minimum and maximum values are significant. This variability may be due to several factors such as conditions of crop, soil type, rainfall and country of origin of the calyx (Kerharo & Adam, 1974; Morton & Roselle, 1987). Variety and compositional differences major components were also observed by Babalola et al. (2001). The calyx of *H. sabdariffa* is rich in organic acids. Succinic, oxalic, tartaric and malic acids are present at respective concentrations of 0.51, 0.43, 0.17 and 0.12 g.100 g^{-1} (Dafallah & al-Mustafa, 1996; Babalola et al., 2001; Wong et al., 2002). Sugars present in calyx of *H. sabdariffa* are glucose, fructose and sucrose. The glucose, with nearly 40% of total sugars, was the most important sugar (Wong et al., 2002).

The presence of β-carotene and lycopene at respectively concentrations of 1.9 mg.100 g^{-1} and 164.3 mg.100 g^{-1} of fresh material has been reported in the calyx of *H. sabdariffa* (Wong et al., 2002). These flowers also contain mucilages and pectins (Forsyth & Simmonds, 1954; Tsai, 1995; Chen et al., 1998) and all essential amino acids (Morton & Roselle, 1987; Glew et al., 1997) (**Table 2**).

Table 2. Amino acid composition (mg.g^{-1} dry matter) of *Hibiscus sabdariffa* calyx

Amino acid	**Calyx**	
	Morton & Roselle, 1987	**Glew et al., 1997**
Arginine	3.60	4.48
Cysteine	1.30	0.87
Histidine	1.50	1.19
Isoleucine	3.00	2.70
Leucine	5.00	4.21
Lysine	3.90	2.77
Methionine	1.00	0.65
Phenylalanine	3.20	2.32
Threonine	3.00	2.36
Tryptophane	-	0.45
Tyrosine	2.20	1.44
Valine	3.80	3.33
Aspartame	16.30	10.50

Glutamine	7.20	8.85
Alanine	3.70	3.46
Glycine	3.80	2.47
Proline	5.60	5.82
Serine	3.50	2.65

One of the characteristics of *H. sabdariffa* is its high anthocyanin content that can reach 1.5 $g.kg^{-1}$ of dry calyx. This content is comparable to that of blackberry and superior to most other edible plants (Mazza & Miniati, 2000) (**Table 3**). The calyx contains two main anthocyanins: delphinidin-3-sambubioside or delphinidin-3-xylosylglucoside or hibiscin and cyanidin-3-sambubioside or cyanidin-3-xylosylglucoside or gossypicyanin, and two minor anthocyanins, delphinidin-3-glucoside and cyanidin-3-glucoside. The delphinidin-3-sambubioside represents 70% of the total content of anthocyanins. The anthocyanins represent the largest group of water soluble pigments in the plant. They are highly valued in the food industry for their coloring properties, which can give food various hues of red and violet (Francis, 1990; Wang et al., 2000). The calyx of *H. sabdariffa* also contains other polyphenolic compounds including protocatechic acid (Herrera-Arellano et al.,, 2004; Dickel et al., 2007). However, anthocyanins of *H. sabdariffa* are known for their instability (Esselen & Sammy, 1975; Tsai & Ou, 1996; Mazza & Miniati, 2000; Chen et al., 2005). The anthocyanins are easily degraded during heat treatments or during storage at room temperature. After heating, the red color gradually changes in brown. This instability is also evident in aqueous solutions and is the main factor limiting the use of extracts of *H. sabdariffa* as colorant in complex food formulations. Greater stability of anthocyanin will permit the market entry as natural colorant which is 940 million US $ (per year), and is growing at the rate of about 5% annually compared to artificial colorant (400 million US $), which increases by only 2-3 % per year (Sarni-Manchad & Cheynier, 2006).

3.2. Microbiological quality

Generally no microbiological problems are noted in the *H. sabdariffa* calyx or in beverages prepared from it (Cisse et al.2009b).

3.3. Product quality perception/requirement by consumers

For drinking, two criteria are essential for consumers, namely the red color of the drink and its acidity. This drink is consumed during hot weather and especially during the month of Ramadan. It can be drunk at any time of day.

Table 3. Some fruits with their major anthocyanins and their content in mg.100g^{-1} of fresh material (Mazza & Miniati, 2000)

Fruits	Anthocyanin	Content (mg.100 g^{-1})
Black chokeberry (*Aronia melanocarpa*)	Cy 3-galactoside Cy3-arabinoside Cy 3-syloside	1050
(*Prunus avium var. Bigareau*)	Cy 3-rhamnoglucoside Cy 3-glucoside Peonidin 3-rutinoside	350-450
Sweet cherry(*Prunus cerasus L. var. Montmorency*)	Pn 3-rutinoside Cy 3-glucoside Cy 3-rutinoside Cy 3-sophoroside Cy 3-2^{G}glucosylrutinoside	35-82
Prune (*Prunas salicina cv. Sordum*).	Cy 3-rhamnoglucoside Cy 3-glucoside	29.5
Blueberry (*Vaccinium corynbasum L.*)	Dp 3-galactoside Dp 3-arabinoside Mv 3-galactoside Mv-arabinoside	25-495
Cranberry (*Vaccinium macrocarpon Ait*)	Pn 3-galactoside Pn 3-arabinoside Cy 3-galactoside Cy 3-arabinoside	78
Black raspberry (*Rubus spp. Var Cumberland*)	Cy 3-glucoside Cy 3-rutinoside Cy 3-sambubioside Cy 3-xylosylrutinoside	428
Strawberry (*Fragaria spp.*)	Pg 3-glucoside Cy 3-glucoside	450-700
Grappe (*Vitis vinifera L.)*	Mv 3-monoglucoside Pn 3-monoglucoside Dp 3-monoglucoside Mv 3-monoglucoside-p-coumarate Pn 3-monoglucoside-p-coumarate	30-750
Hibiscus sabdariffa	Dp 3-xylosylglucoside Cy 3-xylosylglucoside Dp 3-glucoside Cy 3-glucoside	150
Blackberry (*Rubus fruticosus L.*)	Cy 3-glucoside Cy 3-rutinoside	67-230
Blood orange (*Citrus sinensis L., Rutaceae*)	Cyanidin 3-glucoside cyanidin 3-(4”-acetyl)-glucoside	70-100

Conclusion

The *Hibiscus sabdariffa* industry has large potential in Senegal through the increasing market for its producers and exporters. However, it suffers from a lack of organization, information and support to improve its productivity. The industry is also facing several problems such as low availability of certified seeds, poorly controlled post-harvest technology and the lack of industrial or semi-industrial products manufactured locally.

The perspectives on research and required research innovations can be declined in different ways:

- More appropriated scouring, drying and aqueous extraction methods are still needed to obtain higher quality of calyx and drinks;
- To my knowledge no research has been done on the possible increase in value of bioactive components such as anthocyanins by processing technology;
- A research study investigating the stabilization of local drink production from *H. sabdariffa* must be performed. These results will increase the shelf-life of the *H. sabdariffa* drinks and will boost the economic profit for enterprises in this area for exportation possibility.
- A research study focused on a new product such as a natural colorant will also be performed.

Reference:

Anon., Rapport annuel 2000, ISRA, Dakar, Sénégal, 2001, 78 p.

Babalola S.O., Babalola A.O. & Aworh O.C. 2001. Compositional attributes of the calyces of roselle (*Hibiscus sabdariffa*), *J. Food Technol. Afr*. 6 (4), 133–134.

Chen H.H., Tsai P.J., Chen S.H., Su Y.M., Chung C.C. & Huang T.C. 2005. Grey relational analysis of dried roselle (*Hibiscus sabdariffa* L.), *J. Food Process. Preserv.* 29, 228– 245.

Chen S.H., Huang T.C., Ho C.T. & Tsai P.J. 1998. Extraction, analysis, and study on the volatiles in roselle tea. *J. Agric. Food Chem.*46, 1101–1105.

Cisse M, Dornier M., Sakho M., Diop C.M., ReyneS M. & Sock O. 2009a. La production de bissap (*Hibiscus sabdariffa*) au Sénégal *Fruits,* 64, p. 111–124

Cisse M, Dornier M., Sakho M., Ndiaye A., Reynes M. & Sock O. 2009b. Le bissap (*Hibiscus sabdariffa* L.) : composition et principales utilisations *Fruits,* 64, (3) p. 179–193

D'Heureux–Calix F. & Badrie N. 2004. Consumer acceptance and physicochemical quality of processed red sorrel/roselle (*Hibiscus sabdariffa* L.) sauces from enzymatic extracted calyces. *Food Serv. Technol.* 4, 141– 148.

Dafallah A.A. & al-Mustafa Z. 1996. Investigation of the anti-inflammatory activity of *Acacia nilotica* and *Hibiscus sabdariffa*. *Am. J. Chin. Med.* 24 (1), 263–269.

Dickel M.L., Rates S.M.K., Ritter M.R., 2007. Plants popularly used for loosing weight purposes in Porto Alegre, South Brazil. *J. Ethnopharmacol*. 109, 60–71.

Esselen W.B. & Sammy G.M. 1975. Applications for roselle as a red food colorant. *Food Prod. Dev.* 9, 34–40.

Forsyth W.G.C. & Simmonds N.W. 1954. A survey of anthocyanins of some tropical plants, *Proc. R. Soc.* 142, 549–553.

Francis F.J. 1990. Colour analysis, in: Nielsen N.N., Food Analysis, Aspen Publ., Gaithersburg, MD, USA, pp. 599–612.

Glew R.H., VanderJagt D.J., Lockett C., Grivetti L.E., Smith G.C., Pastuszyn A. & Millson M. 1997. Amino acid, fatty acid, and mineral composition of 24 indigenous plants of Burkina Faso. *J. Food Compos. Anal.* 10, 205–217.

Guèye M.,2005 Le bissap une plante d'avenir, *Rural.-Bull. Trimest. ANCAR* 1 14–15.

Herrera-Arellano A., Flores-Romero S., Chavez-Sotoc M. & Tortoriello J. 2004. Effectiveness and tolerability of a standardized extract from *Hibiscus sabdariffa* in patients with mild to moderate hypertension: a controlled and randomized clinical trial. *Phytomed.* 11, 375–382.

Kerharo J. & Adam J.G. 1974. La pharmacopée sénégalaise traditionnelle. Plantes médicinales et toxiques, Vigot Frères, Paris, France.

Lorenzo D., Atti-Serafini L., Santos A., Frizzo C.D., Paroul N., Paz D., Dellacassa E. & Moyna P. 2000. *Achyrocline satureioides* essential oils from southern Brazil and Uruguay. *Planta Medica* 66, 476–477.

Mazza G. & Miniati E. 2000. Anthocyanin in fruits, vegetables and grains, CRC Press, Boca Raton, FL, USA.

McClintock N.C. & El Tahir I.M. 2004. *Hibiscus sabdariffa* L., in : Grubben G.J.H., Denton O.A. (Eds.), PROTA 2 (*Plant Resources of Tropical Africa*): vegetables [CD-Rom], PROTA Wagening., Neth..

Morton J.F. & Roselle, M.J. in: Dowling C.F. (Ed.), 1987. Fruits of warm climates, Media, Inc., Greensboro, NC, USA, pp. 281–286.

Nyarko G., Bayor H., Craigon J. & Suleimana I.A. 2006. The effect of container types, seed dressings and desiccants on the viability and vigour of roselle (*Hibiscus sabdariffa* L var. *sabdariffa*) seeds. *Pak. J. Biol. Sci.* 9 (4), 593–597.

Sarni-Manchad P. & Cheynier V. 2006. Les polyphénols en agroalimentaire, Éd Tec & Doc., Coll. Sci. & Techn. Agroaliment., Lavoisier, Paris, 398 p.

Tsai P.J. 1995. Studies on the color deterioration of roselles during post harvest handling, drying and storage, Natl. Chung Hsing Univ., Ph. D diss., Taiwan.

Tsai P.J. & Ou A.S.M. 1996. Colour degradation of dried roselle during storage. *Food Sci.* 23 629–640.

Wang C.J., Wang J.M., Lin W.L., Chu C.Y., Chou F.P. & Tseng T.H. 2000. Protective effect of *Hibiscus* anthocyanins against tert-butyl hydroperoxide-induced hepatic toxicity in rats, *Food Chem. Toxicol.* 38, 411– 416.

Wong P.K., Yusof S., Ghazali H.M. & Che Man Y.B. 2002. Physicochemical characteristics of roselle (*Hibiscus sabdariffa* L.), *Nutr. Food Sci.* 32, 68–73.

Literature review and Background information

of

Kitoza

Rakotozafy, Z., Sarter S., Jeannoda, V et Rakoto, D.

Edition:

Joseph D. Hounhouigan

Annali Jacobs

Contents

Abstract:

Kitoza is a zebu or pork meat dish that is very popular throughout Madagascar, where it is sold as a raw, fried, dried and/or smoked product. Different types of producers supply markets in Antananarivo with *kitoza*, including beef and pork butcheries, and a few modern production units. Homemade *kitoza* is also prepared according to peoples'preferences from fresh raw meat, to which salt, spices (garlic, pepper, ginger) and sometimes oil may be added. In all cases, the biochemical and microbiological quality of *kitoza* is not controlled.

Introduction:

Salted/dried *kitoza* is generally prepared with beef, especially from the hump of Malagasy zebus. Pork-based *kitoza* is usually found on the menu of *vary amin'anana* street eateries.

Cattle are mostly raised for meat production in Madagascar. A variety of techniques are used for the preparation and/or preservation of beef meat. This ranges from the production of *kitoza* (dried strips of meat), *varanga* (fried shredded meat) and *jaka* (meat preserved in fat). In the Sakalava (western Madagascar) and/or Tsimihety (north) regions, *maskita*, which resembles *kitoza*, is prepared by a sun-drying or hearth-smoking process (Raharolahy 2004). However, it is known that preserving meat in hot countries is often a very difficult task because of the highly perishable nature of this foodstuff, the lack of suitable cold storage infrastructures, and especially the climatic and environmental conditions that precipitate rapid degradation of this product (Yacouba 2010).

In Madagascar, meat is dried and/or smoked on a family household scale, and housewives throughout Madagascar know how to prepare *kitoza* (Laurent 1981).

Kitoza consumption has currently increased because of its ready availability in beef and pork butcheries, street eateries and supermarkets. Hygienic conditions during the preparation and preservation stages and the microbiological quality of the finished products are, however, not controlled.

1. Traditional meat processing for *kitoza*

1.1 Raw materials and additives

Kitoza is prepared with beef or pork. The main ingredients are salt and spices, such as garlic, pepper and ginger. Some producers coat the meat strips with oil.

1.2 Description of the production method

Kitoza is obtained after trimming and slicing beef or pork meat into approximately 3–4 cm thick and 20 cm long strips. Then the strips are uniformly salted. Depending on the preference, spices such as garlic, pepper and ginger may be added to enhance the taste and tenderize the meat.

The meat strips are then threaded onto a cord and hung over a fire (fireplace or barbecue) in order to smoke the meat for at least 24 h. In butcheries, *kitoza* is hung on a cord and then air dried at room temperature. In Imerina region, all air- or sun-dried meat is called *kitoza*, even though the product is smoke-cured (called *saly* in the coastal regions of Madagascar) (Molet 1982).

1.3 Major problems with the product

It is often very hard to preserve meat in hot countries because of the highly perishable nature of this foodstuff, the lack of suitable cold storage infrastructures and especially the climatic and environmental conditions, which are conducive to rapid degradation of this product Yacouba 2010).

Preservation is generally aimed at maintaining the sanitary quality, as well as the taste and nutritional properties of foodstuffs. Meat preservation processes are thus based on slowing down or inhibiting different microbiological, enzymatic and chemical alteration processes (UNESCO data 1986, Touzi et al. 2008).

Meat preservation processes used in hot countries, such as drying, salting, smoking, frying or fermentation, are inexpensive. Most meat-based products are obtained through a combination of these processes (Yacouba 2010).

According to Kalilou (1997), some authors classify these products according to treatments associated with drying, e.g. unsalted dried meats, salted and/or smoked dried meats (including *kitoza*), meats preserved by frying and dried fermented meats.

There are two main advantages to drying meat:

- reducing moisture activity in the processed product, thus inhibiting the development of microorganisms and enzymatic reactions
- reducing the weight and volume of the product, thus facilitating its preservation, transport and storage (Yacouba 2010).

1.4 Preservation and storage

Kitoza may be preserved by hanging it on a cord, generally over a fire. Once dry, it may be preserved for a few weeks to months.

Traditionally, meat exposed to a hearth fire for a very short period, so it is still almost raw, is called *masa-boboka*. Then when cooked, it is called *masaka*. It can even be burnt (*may*), charred (*kila*) or transformed into meat charcoal (*arin-kena*).

Smoking is one of a group of very ancient meat preservation processes. The operation involves subjecting meat to the direct or indirect action of smoke produced by the combustion of certain plants. The simplest smoking method involves processing meat over an open fire (Garba et Kakalo 1996, Yacouba 2010). Smoke particles have a positive effect on the product taste and colour (Maas-van Belkel et al. 2005). The advantages of this practice are threefold:

partial drying of the meat, preservation of the meat due to phenolic smoke compounds and hampering insect infestation (especially flies) of the meat.

The meat pieces should not be very thick, to ensure that they will be smoked to the core. The meat is sometimes salted before the smoking operation, e.g. when preparing Malagasy-style *kitoza* (Laurent 1981). It is the drying and cooking of the product during smoking that is most important during the preservation process (Maas-van Belkel et al. 2005).

Smoking produced by wood combustion contains fungistatic agents that inhibit mould and yeast growth on the product surface. When dried meat is stored, especially in humid climatic conditions, it can be subjected to a light smoking process. However, smoking does not have a substantial preservation effect if the product is not also stored in a cold chain (FAO 1990).

2. Socioeconomic importance of *kitoza*

2.1 Production areas

In Sakalava region (western Madagascar) and/or Tsimihety (north), *maskita*, which resembles *kitoza*, is produced by a sun-drying or hearth-smoking process (Raharolahy 2004).

2.2 Socioeconomic profile of stakeholders

In Madagascar, meat is smoked on a family household scale, and housewives throughout Madagascar know how to prepare *kitoza* (Laurent 1981).

Different types of producers supply markets in Antananarivo with *kitoza*, including beef and pork butcheries, and a few modern production units.

2.3 Socioeconomic importance of the product

Most housewives in Madagascar know how to prepare *kitoza* by this traditional method. The most important point is that the meat must be lean (Laurent 1981).

According to the literature, *kitoza* consumption is an ancient custom in Madagascar. This select product was prepared for kings and nobility. When the *kitoza* quantities were excessive, the leftovers were distributed to the people (Callet 1902, Mondain et Chapus 1948).

2.4 Marketing

The *kitoza* market in Antananarivo is rapidly expanding. It is now widely sold in beef butcheries and street eateries, as well as in pork butcheries and supermarkets throughout the capital. This trend indicates that the product is highly appreciated by all types of consumers, Malagasy people of different living standards and even foreigners. This could likely be explained by the fact that *kitoza* is a pre-prepared ready-to-cook dish, and also very tasty.

3. Quality features of *kitoza*

The specific methods used to prepare (addition of ingredients) and preserve (especially smoking) *kitoza* enhance its biochemical traits and microbiological quality.

Smoking, in addition to preservation by drying, modify the organoleptic qualities of the meat, i.e. changing its colour, aroma and hardening its texture (FAO 1990). Smoking introduces formaldehyde, which acts as a preservative while also improving the taste of the meat (http://fr.wikipedia.org/wiki/Fumage).

Smoke produced by wood combustion contains fungistatic substances that inhibit mould and yeast growth on the surface of the product (FAO 1990).

Moreover, intense smoking can considerably lengthen the shelflife of meat, but it also has an unfavourable effect on the taste and thus the quality, especially during long storage, when unpleasant tar-smoke aromas gradually develop (FAO 1990).

Salting hampers the development of microorganisms on the product surface, while also repelling insects and other parasites (Maas-van Belkel et al. 2005, Yacouba 2010).

No accurate assessment of *kitoza* quality has been carried out to date in Madagascar, but this should now be considered.

4. Consumption of *kitoza*

4.1 Types of consumption

In Antananarivo, *kitoza* is sold in different forms: raw in butcheries, cooked in street eateries, dried and smoked in supermarkets.

Kitoza is eaten with *vary amin'anana* (rice broth and leafy vegetables) or *vary sosoa* (rice broth).

4.2 Consumption periods

This dish is appreciated by people throughout Madagascar, but it is usually eaten in the morning for breakfast and the evening for supper with *vary amin'anana* (rice broth and leafy vegetables) or *vary sosoa* (rice broth). This dish is also currently recommended for nursing mothers.

5. Research activities

As *kitoza* quality has yet to be studied, research should be focused on the biochemical and microbiological properties (pathogenic bacteria, lactic bacteria, yeasts and moulds) at different production stages. For smoked *kitoza*, a toxicological study of polycyclic aromatic hydrocarbons (PAH), including benzoapyrene from smoke and which is mutagenic and carcinogenic, could be carried out.

The literature research has been done with the following keywords: Kitoza ; Meat or beef or pork and madagascar or malagasy ; Dried meat nor ham nor sausages ; Ripened meat ; Raw cured meat product ; Raw dried meat ; Air dried beef ; Meat and drying ; Fermented meat.

Conclusion

Kitoza has been eaten in Madagascar since its introduction long ago by the royal families, and the popularity of this dish is still rising. *Kitoza* production could be industrialized in compliance with international health standards so as to enable its exportation worldwide.

References:

A. Touzi et A. Merzaia-Blama. 2008. La conservation des denrées agro alimentaires par séchage dans les régions sahariennes, Revue des Energies Renouvelables SMSTS’08, Alger. pp267–272.

Callet, R.P.1902. Tantaran’Andriana. Bulletin de l’Académie Malgache, N°3, p166.

Document, UNESCO, ‘La Recherche Scientifique et l’Agriculture de Demain’, Impact: Sciences et Société, UNESCO, Paris, N°142, Vol. 36, N°2, 1986.

FAO. 1990. Manual on simple methods of meat preservation, (ISBN 92-5-102744-7), p. 48.

Fumage de la viande : http://fr.wikipedia.org/wiki/Fumage

Garba H. et Kakalo S. 1996. Contribution à l'étude des procédés traditionnels de fabrication du kilichi au Niger, Mémoire de fin d'études, faculté d'agronomie, université Abdou moumouni de Niamey, 40 pages.

Kalilou S. 1997. Transformation traditionnelle de la viande en kilichi au Niger, optimisation des procédés, thèse de doctorat, Montpellier, France, 137.

Laurent C. 1981. Conservation des produits d'origine animale en pays chauds, ACCT - Paris (France), 157 pages.

Maas-van Belkel B., van den Boogaard B. et Heijnen C., 2005. Conservation de viande et poisson, Agrodok 12, Fondation Agromisa, Wageningen, Pays-Bas, 90 p.

Molet L. 1982. Le feu domestique et la cuisine chez les merina (Madagascar), vol IX, p49-66

Mondain, G., et Chapus, G.S. 1948. Historique du bœuf d'après les Tantaran'Andriana. Bulletin de l'Académie Malgache, N°27, pp191-223.

Raharolahy L. 2004. Le bœuf dans la société traditionnelle malgache.

Yacouba I. 2010. Analyse des techniques traditionnelles de transformation de la viande en Kilichi dans la commune urbaine de Madaoua (rep. du Niger). 51p

Literature review and Background information

of

Kenkey

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:

Kofi Amoa-Awua, W., Oduro-Yeboah, C., Halm, M., Jakobsen*, M.

Food Research Institute, Council for Scientific and Industrial Research, Post Office Box M.20, Accra, Ghana

* Faculty of Life Sciences, University of Copenhagen, Denmark

Edited by: Annali Jacobs, Joseph Hounhouigan, Christian Mestres

December 2010

Table of contents

Abstract

Traditional processing of foods, including the production of indigenous fermented foods, is an important activity in the informal sector of the Ghanaian economy. It provides a means of livelihood for a large number of traditional food processors in the rural areas and increasingly in urban areas in recent times. One of the most important of these indigenous Ghanaian fermented foods is kenkey, which is a sour stiff gruel or dumpling made from fermented maize dough which is wrapped in leaves and boiled. Kenkey is consumed all over Ghana but especially in the southern coastal areas where it has originated from. There are two main types of kenkey produced from maize and these are Ga Kenkey and Fanti Kenkey. Both are cooked sour tasting stiff porridges with a pH of about 3.7, moisture level of between 52-55% and usually eaten with sauce and fish. During the production of kenkey, the dough is divided into two parts: one part, the *aflata* is cooked into a thick porridge, while the other uncooked part is later mixed with the *aflata*. The resulting mixture is moulded into balls and wrapped in dried maize husk or plantain leaves, after which it is boiled. It is interesting to note that kenkey products vary widely throughout Ghana. Ga kenkey is fermented for 2-3 days, salted, cooked, wrapped in maize husks and has a shelf-life of about 3 to 4 days. Fanti kenkey, which has a shelf-life of about one week, is fermented for 3 -4 days, not salted and cooked wrapped in plantain leaves. In addition to Ga and Fanti kenkey a few other types of kenkey are also produced, but these are mainly produced from dehulled rather than whole maize grains. Two of such products are *Nsiho* and *Fomfom.*

Kenkey's importance in modern-day life is underlined by the wide spectrum of fermented foods marketed both in developing and industrialized countries, not only for the benefit of preservation and safety, but also for their highly appreciated sensory attributes. Fermented foods are treasured as major dietary constituents in numerous developing countries, primarily because of their keeping quality under ambient conditions, and also for their safety and traditional acceptability.

Several studies have been carried out to upgrade and mechanize some of the unit operations involved in the production of kenkey, including the development of shelf-stable dehydrated fermented maize meal flour as a convenience intermediary product.

Introduction

Kenkey is an indigenous fermented product commonly produced in Ghana, West Africa, especially in the coastal areas. Traditionally it has been produced by two ethnic groups, the Gas in the Greater Accra region and the Fantis in the Central and Western regions. The production of fermented maize products might have developed from a definite attempt of the local population to produce food with a more pronounced flavour than the relatively bland tubers such as yam. Just as bread in Europe, kenkey is of particular importance amongst the poorer people and more so in cities than in country communities. In Accra, Kenkey is only second in importance to fresh cassava. In the Western and Central regions of Ghana it falls into third place after plantain. It decreases in importance in the Eastern, Ashanti and Brong Ahafo regions and in the North, where sorghum rather than maize is grown and little kenkey is consumed (Muller & Nyarko-Mensah, 1972).

There are two types of kenkey, Ga-kenkey (also called *komi*) and Fanti-kenkey (also called *dokono*). Slight differences exist in the organoleptic quality and the processing procedure for the two types of kenkey. Both are produced by the fermentation of maize dough into a sour dough that is subsequently cooked—wrapped in maize husks in the case of Ga-kenkey or plantain leaves in the case of Fanti-kenkey. Fanti-kenkey is fermented for a slightly longer period than the Ga-kenkey, and salt is also added to the latter during processing. In addition to Ga and Fanti kenkey, there are also a few different types of kenkey produced, but these are mainly produced from dehulled or polished maize rather than the whole grains. *Akporhi* or *nsihu* is one such type of polished kenkey produced mainly in the Central, Western and Volta regions of Ghana. It is prepared by dehulling the maize; the dehulled maize is then milled and reconstituted with water to form a dough which is left to ferment for only 24h. Balls are made from this dough and steamed (Whitby, 1968; Dovlo, 1970; Sefa- Dedeh, 1993). *Fomfom* is yet another type of kenkey produced from dehulled maize and is mainly produced in the Western Region of Ghana (Johnson & Halm, 1998).

1.Traditional processing of Kenkey

1.1 Raw materials used in the production of kenkey

Maize is the main raw material used to produce kenkey. It is the principal cereal produced in Ghana and is grown in varying quantities throughout the country as shown in Fig 1. Maize is also consumed as a staple crop in most parts of the country. Its annual production is currently 1,034,200 metric tons, accounting for 3% of the Agricultural Gross Domestic Product. The bulk of the maize produced is consumed in the form of kenkey (Hayford, 1998; Halm et al., 2003).

1.2 Processing of maize into kenkey

The traditional method for the production of both Ga and Fanti kenkey is shown in the flow diagram in Fig. 2 and involves cleaning, steeping, milling, dough fermentation, *aflata* preparation, mixing of *aflata* and raw dough, moulding and packaging, and cooking into kenkey.

Cleaning

Maize for processing into kenkey is cleaned to remove all foreign matter. This is done by one or a combination of several processes including winnowing, handpicking, sieving, and sedimentation. These operations remove dust, chaff, stones, insect-damaged grains, and other debris. The sedimentation process involves pouring the grains into a big basin of clean water, stirring with a wooden ladle to allow the mature and good-quality grains to settle at the bottom while the less dense immature, some insect damaged, and diseased grains float on the surface. The latter are collected with small baskets or sieves and used as

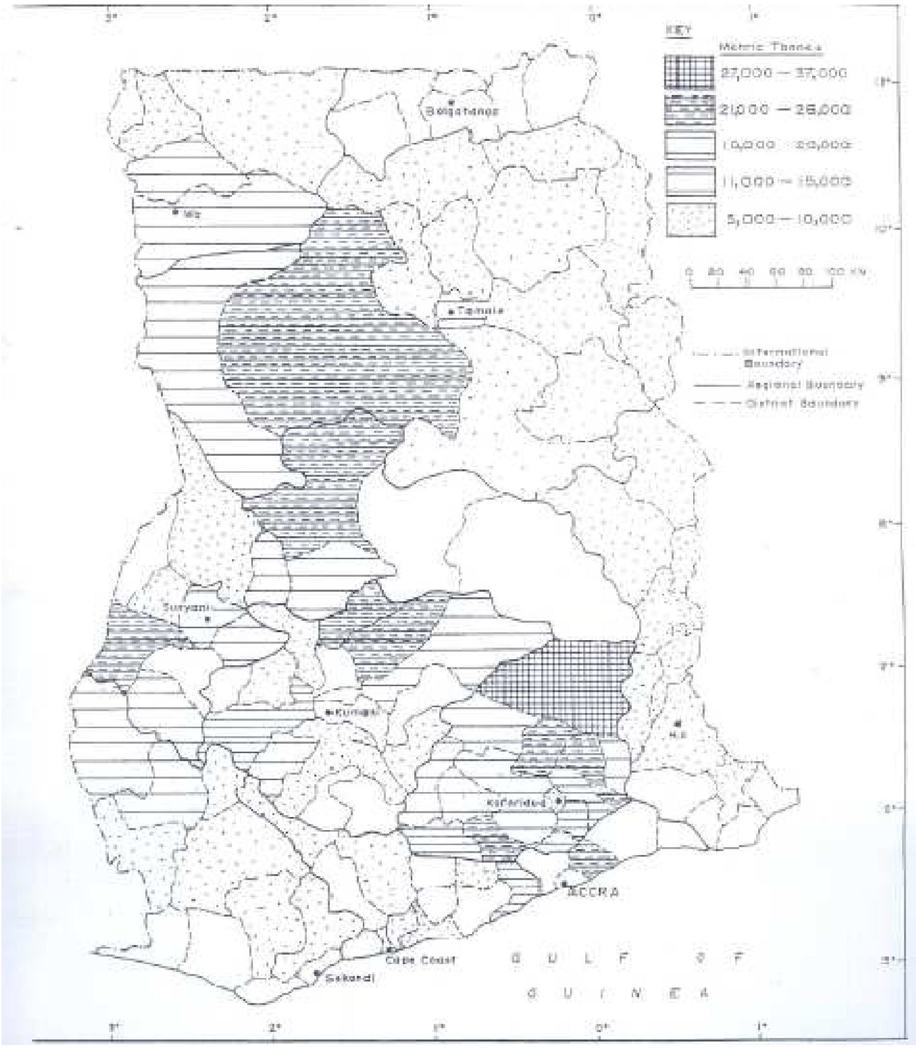


Fig 1. Map of Ghana showing major maize producing areas

Plate 1. Bags of maize to be processed into kenkey
at a large traditional production site.

MAIZE

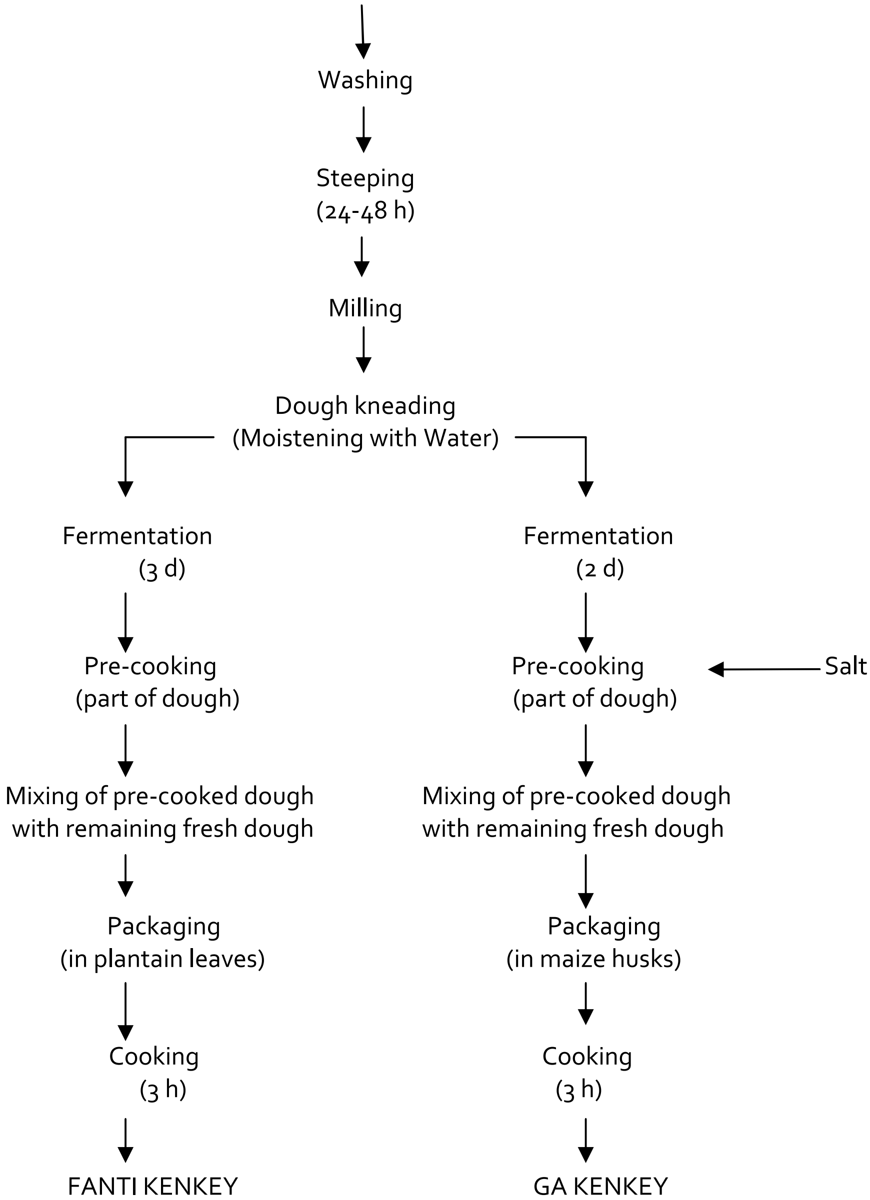


Fig 2. Process flow diagram showing various unit operations in the production of kenkey from maize (Source: Amoa-Awua et al., 1998)

animal feed. The good maize is washed again in water before steeping (Halm et al., 2003).

Steeping

This involves the steeping of the maize grains in clean water for 1 to 3 days depending on the initial moisture content and hardness of the grains. Most local varieties are steeped for 1 day, but some hybrid maize with very hard kernels and high portion of testa are steeped for up to 3 days to soften the kernels and facilitate milling. It has been confirmed that soaking of whole maize before milling remains the best option for developing the necessary dough textural characteristics (Akingbala et al., 1987; Nche et al., 1996). The steep water is drained off and the maize washed before milling. Amponsah (2010) has reported a water uptake of 28-29% during the steeping of maize for 24 – 48 h.

Plate 2. Maize being steeped in large aluminium containers at the large traditional kenkey production site

Milling and Doughing (Kneading)

The steeped maize is milled in a plate mill or disc attrition mill popularly known in Ghana as corn mill into a very smooth meal; which is then mixed with water to form a dough with a moisture content of about 50–55%. The amount of water used to form the dough is very important as this affects the rate of fermentation as well as the quality and shelf life of the dough. This amount varies widely from one producer to another, between 17 and 44 liters of water to 100 kg of maize (Allotey, 1996). Plahar & Leung (1982) demonstrated that low moisture content of 45% reduced the rate of acid production to 1.4 mg NaOH g^{-1} instead of about 2.2 mg $NaOH^{-g}$and early onset of mould growth, while high moisture content of 65% and 80% developed high concentration of acids and subsequently a high degree of sourness.

Fermentation

The dough is packed tightly into wooden vats, aluminium pots, enamel or aluminium basins or plastic containers and allowed to ferment spontaneously for up to 3 days at ambient temperature (i.e., 25–30◦C). The size of the fermenter is variable, but it will normally not exceed 50 kg of dough. Normally, after 2 days of fermentation, the dough is ready for use in making different products including kenkey, *banku* and *koko*. Dough

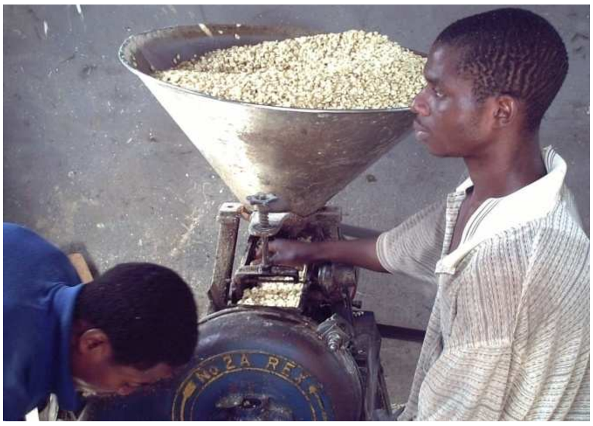


Plate 4A. Milling of steeped maize

Plate 4B. Kneading of milled maize into dough

fermented for 24h does not give a good-textured product, but this can be mixed with older dough to obtain the desired texture. Sometimes the traditional processors hasten the fermentation by back-slopping with old dough. With back-slopping, fermentation can be shortened to 24 hr.

Usually the processors use up all the fermenting dough between the second and third day, but if fermentation is prolonged beyond the third day it might lead to the development of undesirable flavours and high acidity. However, according to some commercial producers, the shelf life of the dough can be extended without adverse effect on consumer acceptance if less water is used in making the dough. The dough may also be sun-dried after the desired acidity of 2.2 to 2.5 mg $NaOH^{-g}$has been obtained within 2 days. Commercial producers of kenkey do not advise using 24h dough kenkey, however, this can be mixed with over-fermented dough (3 days) and used for kenkey to give the desired characteristics (Halm et al., 2003). Some large scale producers encourage "back-slopping" as means of facilitating fermentation, by adding old dough to fresh dough. This leads to a shorter fermentation time of 24h and the dough seems to attain all the desired characteristics within this time (Nout et al., 1996). Three days seems to be the maximum time for the fermentation. Extended times often result in undesirable characteristics such as undesirable flavours and high acidity with extreme sourness (Halm et al., 2003).

Plate 5. Fermenting maize dough

Aflata Preparation and Mixing

A portion of the fermented dough is made into a slurry by adding two or three parts of water and cooked/boiledwith continuous stirring (about 20 mins for 1.5 kg of dough) into a sticky gelatinous paste known as *aflata*. During this process, salt is added in the case of Ga-kenkey. The *aflata* is mixed thoroughly with a portion of the uncooked fermented dough using wooden ladles and allowed to cool. The ratio of *aflata* mixed with uncooked dough depends on the type of kenkey being produced and the preference of the consumers. Amongst the indigenous Ga people who consume kenkey as a major staple, the ratio of *aflata* to the uncooked dough is usually 1 to 1. However, some producers mix two-thirds of *aflata* with one-third of the uncooked dough, and others mix one-third *aflata* with two-thirds uncooked dough. The ratio of *aflata* mixed with the uncooked dough determines the texture of the kenkey that will be produced. In a sensory evaluation of the texture of kenkey, the highest score was given by panellists for kenkey prepared from a 1-to-1 *aflata* to uncooked dough mixture (Bediako-Amoa & Muller, 1976). The study confirmed that aflatalisation is necessary to produce kenkey of the desired texture. *Aflata* is reported to act as a binding agent when mixed with uncooked fermented dough and enables the product to be moulded into balls and other shapes (Sefa-Dedeh & Plange, 1989). Aflata acting as a binding agent also gives kenkey its firm and semi-sticky consistency (Sefa-Dedeh, 1993)

Moulding and Packaging

For Ga-kenkey the mixture is moulded into balls of uniform sizes of about 300 g weights and wrapped in clean pre-wetted maize husks. Fanti-kenkey is moulded into rectangular shapes, placed in a polyethylene bag and then wrapped with plantain leaves (Halm et al. 2003).

Plate 6. Moulding of Ga-kenkey into balls

Cooking

Some clean maize husks or plantain leaves are placed at the bottom of large aluminium cooking pots and the balls of kenkey are packed on top to prevent the balls from sticking to the pots during cooking. Boiling water is poured into the pot to cover the balls and the top covered with a piece of cloth or polyethylene sheet to conserve steam. The kenkey is cooked for about 3 to 3.5hours. The length of cooking depends on the ratio of *aflata* to the uncooked dough and how well the *aflata* was cooked. For kenkey containing less *aflata*, boiling lasts longer. After the balls are well cooked, they are removed from the pots and placed in large bowls lined with polyethylene sheets, which are also used to cover the balls of kenkey to keep them hot until they are all sold for consumption. The cooking water left in the pot, referred to as kenkey water is collected and drunk as a thin porridge and is believed to have curative properties against malaria, diarrhoea and jaundice. It has been reported that the carbohydrate and electrolyte levels of kenkey water are comparable to the UNICEF/WHO Oral Rehydration Salts and therefore suitable for use in oral rehydration in Ghana (Yartey et al., 1993).

Plate 7. Traditional cooking of Ga-kenkey

Plate 8. Cooked Ga-kenkey

Processing of maize into Nsiho or Akporhi

Nsiho or *akporhi* is a dumpling similar in consistency to kenkey. It is a popular product in the Western and Central regions of Ghana made from dehulled maize. The process flow diagram for the production of *nsiho* is shown in Fig 3. In the processing of *nsiho* dry maize is cleaned of foreign matter and tempered with a little quantity of water. The conditioned maize is then dehulled in a disc attrition mill and winnowed to remove the hulls and chaff. The dehulled maize is washed and steeped in water for 24 h. The steep water is drained off and the maize is milled once into a smooth meal in a disc attrition mill, mixed with water to form a dough of 50-55% moisture content and allowed to ferment for 6 to 24h. The period of fermentation can be reduced to 6 hours when the steep water is used in forming the dough. After fermentation, one half of the dough is cooked into a paste known as *aflata,* which is mixed with the remaining half uncooked dough, and moulded into balls. The balls are packaged in plantain leaves and cooked for up to 2 h or more to give *nsiho* (Whitby, 1968; Dovlo, 1970; Sefa-Dedeh, 1993; Johnson & Halm, 1998).

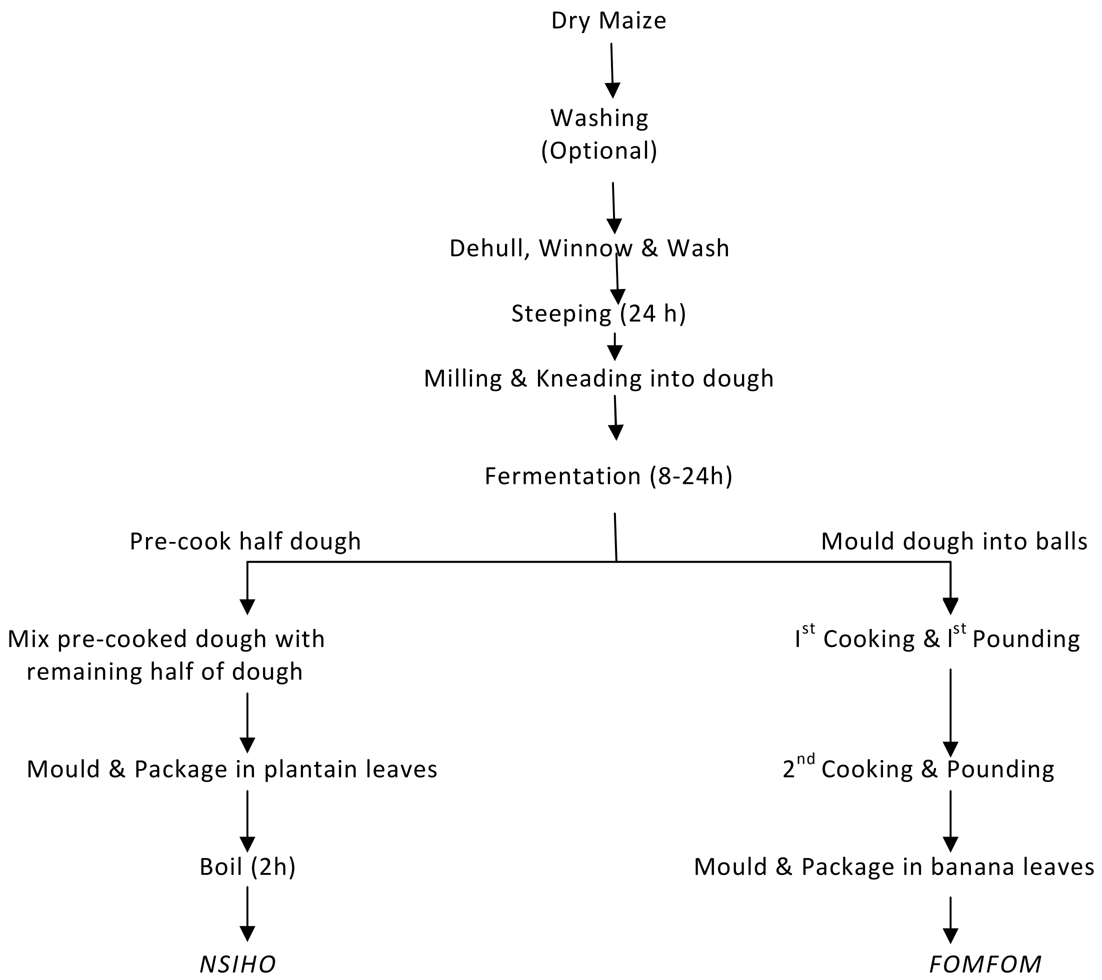


Fig 3. Process flow diagram showing the production of *Nsiho* and *Fomfom* from maize. (Source: Johnson & Halm, 1998)

Processing of maize into Fomfom

The traditional procedure for processing maize into fomfom is shown in Fig 3. Fomfom is a stiff porridge similar to kenkey in consistency but made from dehulled maize. Maize is dehulled in a disc attrition mill and milled as for *nsiho.* The meal is mixed with water to form a dough containing 50-55% moisture and an inoculum of old dough is added to shorten the fermentation period from 24 h to 6-9 h. The fermented dough is shaped into balls with holes made in the centre. The balls are cooked twice in boiling water. After each boiling, the balls are pounded in a mortar. After the second pounding, the mass is moulded into balls and packaged in banana leaves ready for consumption. This product is popular in the Western region of Ghana (Johnson & Halm, 1998; Halm 2006).

1.3 Major problems associated with processing methods

The major problems with kenkey production and consumption are contamination with aflatoxins and other mycotoxins from maize grains and corn husks used for processing, survival and growth of spoilage organisms during steeping and fermentation and physical contamination with various foreign materials and items (Kpodo et al., 1996; Amoa-awua et al., 1998).

Maize sold on the open market is often contaminated with moulds, including mycotoxin-producing species such as *Aspergillus flavus* and *Aspergillus parasiticus*, which produce aflatoxins, and *Penicillium citrinum*, which produces citrinin (Jespersen et al., 1994; Kpodo et al., 1996). The occurrence of aflatoxins in maize and maize products in Ghana has been reported by Kpodo et al (1996) and is a matter of public health concern. According to Kpodo et al (1996) contamination of maize with moulds is largely dependent on the moisture content of the grains and storage conditions. Maize sold on the open market is also often contaminated with fumonisins produced by some *Fusarium spp*. (Kpodo, 2000; Kpodo et al. 2000). Field infestation of maize with moulds may occur if there is intermittent rain during the period that mature maize is left to dry on the field before harvest. However, prompt harvesting of mature grains and mechanical drying to a moisture content of not more than 12% and efficient storage prevents mould growth. The prolonged cooking of kenkey for about 3 hr destroys some mycotoxins which may be present such as citrinin. However aflatoxins are heat-stable and survive the process even though there is reduction in their total level (Kpodo et al., 1996).

The second problem encountered in kenkey production is the risk of spoilage of steeped grains and fermented dough due to growth of spoilage microorganisms. Proliferation of such microorganisms in the products may result in an economic loss to the producer, because the organisms produce strong offensive odours, which are not acceptable to consumers. The growth and survival of the spoilage microorganisms is favoured by higher pH values. A rapid drop in pH to acidic conditions as a result of the fermentation during steeping minimizes the occurrence of this problem (Amoa-Awua et al., 1998).

A third problem in kenkey production is the survival and growth of pathogenic microorganisms even though the lactic acid fermentation of maize during kenkey has been shown to have antimicrobial effects against major bacterial food pathogens (Mensah et al., 1991; Halm et al., 2004; Halm 2006). The prolonged cooking of kenkey for about 3 hr is drastic enough to destroy any surviving pathogenic bacteria and most of their toxins.

Maize purchased in sacks from the open market often contain a lot of debris such as broken cobs, soil, pieces of nylon thread used to knit the open end of the sacks and other foreign material. Processors handle large quantities of maize, so they find it rather tedious to clean the maize by sifting and picking out unwanted materials manually. Maize cleaning is therefore often carried out inefficiently. Hazardous materials may also occur in the form of metal pieces broken off from the grinding plates of the plate mill during milling.

1.4 Storage methods, maximum duration and problems associated with storage

Cooked kenkey balls are placed in a big container lined and covered with polyethylene sheets to preserve heat until sold. Kenkey has a moisture content of about 62-68%, pH 3.7 titratable acidity of 2.2 to 2.5 mg NaOH g^{-1} and shelf-life of about 3 to 4 days with no refrigeration (Hayford, 1998). Fanti kenkey however has a slightly longer shelf life and can be stored for about 5 to 9 days under ambient conditions (Atople, 2006)

2. Socio-economic importance

2.1 Production, processing, handling and storage zones identified in the country

The process of kenkey-making is lengthy and laborious; therefore it is more often purchased from a commercial kenkey producer rather than cooked at home. The producers, who are mainly women with little or no formal education, carry out commercial production as a family-acquired art. The small-scale processors carry out their activities either as individuals or as a family business in the household, often depending on family labour to produce and retail the product. In a survey conducted in Accra, Allotey (1996) found that at most production sites the amount of maize processed weekly ranged from 0.05 to 1.2 metric tons with an average of 0.3 tons of maize processed into 0.5 tons of kenkey. There are however, a few large production sites with weekly capacities of several tons (up to 5 tons) of maize. Such large production sites do not only produce kenkey for sale, but also sell the intermediate product, the fermented dough, which is also used to prepare other products such as *koko* and *banku*. The production of kenkey is based on traditional technologies, which have been handed down in generations. Production costs, apart from the raw material, maize, are minimal, because the family labour employed is often not perceived as costs. This makes the product affordable, providing food for a large part of the urban population especially the low-income group.

2.2 Socio-economic profile of kenkey processors and retailers

Traditional processing of foods, including the production of indigenous fermented foods, is an important activity in the informal sector of the Ghanaian economy. It provides a means of livelihood for a large number of traditional food processors in the rural areas and increasingly in urban areas in recent times. Despite the importance of traditional food processing, several issues including the food safety aspects of their operations are of concern to the regulatory authorities and attempts are being made to improve their operations (Amoa-Awua et al. 2007). According to Sefa-Dedeh (1993), these traditional food processing technologies have strong links with the rural traditional environment and even though they employ the same principles and unit operations as those found in modern food technology, their mode of application may be different. For most products the processing technologies may be at a rudimentary stage using simple techniques and implements and the operations are home based with women as the major executors (Sefa-Dedeh, 1993). Lartey (1975) lists the disadvantages of the indigenous technologies to include high labour input, uneconomical operations, low efficiency, time consuming nature of the processes, and lack of quality assurance. According to Halm, Amoa-Awua & Jakobsen (2003), the underlying fermentation processes of the indigenous African fermented foods, provide foods of highly appreciated properties and represent an art of food preparation and preservation, which has substantial socio-economic impact in West African societies.

The informal food processing sector in Ghana, including kenkey production, is dominated by traditional food processors who operate on a cottage level or rural /small-scale level. These traditional food processors produce the bulk of processed foods consumed in Ghana using traditional methods to produce indigenous foods. However their operations are being increasingly mechanized to overcome labour intensive activities (Amoa Awua et al., 1998). These kenkey processors make an effort to control factors that affect the quality of kenkey since their share of the market depends upon the quality and reputation of kenkey. For management of the quality of kenkey, traditional processors rely on their own experiences and factors which they are able to control during processing. The traditional kenkey processor plays an invaluable role in maintaining the cultural and social integrity of the Ghanaian society and their activities need to be supported , upgraded and promoted for the social and economic advance of Ghana (Amoa Awua *et al*. 1998).

Kenkey plays an important socio-economic role in African economies in terms of employment potential. Although kenkey vendors come from diverse backgrounds, the majority are female heads of households. Most of these vendors employ other people to assist with the business and thus consider themselves as employers. A study by Tomlins and Johnson (2004) showed trends in terms of the participation of the different groups of people, with women constituting the majority of vendors. However, men are now playing an increasingly prominent role in this lucrative business.

Kenkey vendors operate from various places including municipal markets, cooperative markets, industrial sites, vacant bus shelters and other undesignated sites. Kenkey vending takes place alongside other activities such as the sale of haberdashery and clothes, commuter omnibus ranking, push cart operations, cleaning of commuter omnibuses and the hawking of other items including sweets, tobacco and cigarettes, thereby exposing the food to multiple sources of contamination.

2.3 Socio-economic importance of kenkey

Commercial production and street vending of kenkey is the source of livelihood for many traditional food processors and food vendors in Ghana and these activities make a sizeable contribution to the rural and urban economy in Ghana. Kenkey as a street food is convenient, cheap and affordable for the poor and provides informal and self-employment opportunities as well as supplementary income for the households. The vending of kenkey contributes positively to the food security of all the actors in the chain including maize farmers, input suppliers, kenkey processors and vendors. The kenkey vending business in Ghana starts from the house. A woman with a little capital sets up a structure and kenkey prepared in the home is sold. Kenkey contributes significantly to food security and nutrition and is physically and economically accessible to most people. It is an activity which provides employment to many while providing nutritious, inexpensive and tasty food to millions of women, men, children and students (Tortoe et al., 2008). Kenkey is now a widely eaten food all over Ghana. It is also eaten across other parts of West Africa including the people of Lagos State in Nigeria.

2.4 Commercialisation of kenkey

An indigenous fermented food like kenkey has several inbuilt advantages such as its anti-microbial properties due to the lactic acid fermentation and needs to be patronised and the production methods upgraded to withstand competition with fast foods which continue to gain popularity in urban areas in Ghana. There is therefore a threat posed by the food industries and multi-national corporations, which have the facilities to totally dominate the food processing sector. Since these companies produce mainly international, foreign or non-traditional foods, it is important that the quality and production methods of kenkey are upgraded to a level where it will be absorbed into the formal food sector (Amoa Awua et al., 1998).

3. Quality characteristics of the product

3.1 Nutritional quality

Maize contributes significantly to the total calorific and protein content of the diet of people who consume it as a staple in Ghana and is richer in protein than other staples such as cassava, cocoyams, yams, and plantain. However, the traditional maize varieties are deficient in lysine, tryptophan, and B vitamins (Mertz, 1970). It has been estimated that maize accounts for 90–95% of the total calories and over 70% of the dietary proteins of some people in parts of the coastal areas (Davey, 1962). On a dry-matter basis the proximate composition of Ga-kenkey is roughly 8.9–9.8% protein, 1.3–3.2% fat, 0.5–1.9% ash, 10.6–78.6 mg.100g^{-1} calcium, 202.4–213.8 mg.100 g^{-1} phosphorus, 6.5–12.6% mg.100 g^{-1} iron, and 74.3–87.1% total carbohydrate (Eyeson & Ankrah, 1975; Ahenkora et al., 1995; Obiri-Danso et al., 1997; Annan-Prah & Agyeman, 1997).

Maize as a cereal is low in protein and deficient in lysine and tryptophan. The nutritional value of the maize product kenkey is basically dependent on the variety of maize and the processing technique applied. Processing methods such as soaking, milling, packaging material, cooking and fermentation may either reduce or increase one nutrient depending on the susceptibility of the nutrient in question (Ankrah 1972). A high lysine variety of maize known as " *Obantanpa*" and developed locally is being introduced to raise the level of the nutritive value in maize products (Ahenkora et al., 1995; Obiri-Danso et al., 1997). However, soaking, fermentation and cooking all had an additional increase in available lysine in maize and maize-cowpea fermented dough and, consequently an improved nutrient quality of kenkey (Nche et al., 1994a, 1995). Calcium losses occur during kenkey production; phosphorus content however increases, but due to anti-nutritive factors such phytic acid which bind this mineral, there is a reduction in bioavailability of both phosphorus and calcium.

Kenkey is rich in desirable high fibre low glycaemic index carbohydrates advocated for use in diabetics, because it slowly releases its carbohydrate content over a long time, helping the body manage its carbohydrate requirement for a perfect glycaemic index control. Kenkey is nutritionally rich and especially a good inclusion in diets for diabetics, those with high abdominal fat and indeed any individual who wants to control their weight and shape (http://www.africanfoods.co.uk/buy-ga-kenkey.html).

The fermentation of maize during processing into kenkey may improve the nutritional status of the product by increasing synthesis of B vitamins (e.g., thiamine), protein digestibility and bioavailability of nutrients, among others. It has been reported that soaking of maize resulted in significant increases in lysine availability by about 20% (Nche et al., 1996). Cooking of soaked samples further improved lysine availability by 68%. Fermentation for 2 days further increased lysine availability by 22%. Prolonged fermentation and cooking effected further significant improvements in lysine availability. Nche et al., (1995) reported lysine concentration of 3.42 g N of protein equivalent for maize dough fermented for 4 days and cooked for 3 h. The increased availability of essential amino acids resulting from lactic acid fermentation may be related to a reduction in proteinase inhibitors (e.g., trypsin inhibitor) in legumes and a reduction of tannins (Hamaker et al., 1987, Khetarpaul &Chauhan 1989). Lactic acid bacterial strains isolated from kenkey and other Ghanaian fermented foods have been found to show different abilities to degrade or inactivate trypsin inhibitor under defined conditions (Holzapfel, 1997). *Lactobacillus plantarum strain* 91 and *Leuconostoc* sp. 106 isolated from kenkey were able to degrade trypsin inhibitor by about 50%.

Very little or no change occurs in the level of riboflavin in maize dough during fermentation, whereas cooking maize dough into *banku* and Ga-kenkey results in a mean loss of 33% and 36% riboflavin, respectively (Ankrah 1972; Andah & Muller 1973). The thiamine content, however, is reported to increase considerably during fermentation of maize dough from 339.1 $g.100g^{-1}$ maize to 389.3 A $g.100\ g^{-1}$ fermented dough (Andah and Muller 1973).

3.2 Microbiological quality

In kenkey production, fermentation occurs during the steeping of maize and the fermentation of the dough. Earlier studies on the microbiology of maize dough fermentation during kenkey production carried out in 1970 reported the presence of a mixed population of lactic acid bacteria and yeasts at the advanced stage of fermentation (Christian, 1970). The bacteria consisted of homo fermentative *Pediococcus cerevisiae* and the heterofermentative species *Leuconostoc mesenteroides* and *Lactobacillus fermentum.* Other investigators (Fields et al., 1981) identified the dominating lactic acid bacteria in spontaneous fermentations of whole maize meal under laboratory conditions as heterofermentative *L. fermentum*, *Lactobacillus cellobiosus*, and *Pediococcus acidilactici*.

Studies carried out by Halm et al., (1993) identified the dominant lactic acid bacteria responsible for maize fermentation during kenkey production to be closely related to *L. fermentum* and *Lactobacillus reuteri* based on the pattern of carbohydrate fermentation. Other fermentative organisms identified were *Pediococcus pentosaceus* and *P. acidilactici*. In a later study Hayford et al., (1999) confirmed the dominant lactic acid bacteria to be *L. fermentum* using molecular methods. Some authors have reported the dominance of *Lactobacillus plantarum* in the later stages of maize dough fermentation during kenkey production (Nche et al., 1994; Olasupo et al., 1997). Olasupo et al. (1997) have reported *L. plantarum*, *L. fermentum*, *Lactobacillus brevis* and *Lactobacillus delbrueckii* as the dominant organisms but using biochemical profiling.

With regards to yeasts involved in maize dough fermentation during kenkey production Jespersen et al (1994) reported the presence of *Candida*, *Saccharomyces*, *Trichosporon*, *Kluveromyces*, and *Debaryomyces.* The species of the dominant yeasts involved in the fermentation of maize during processing into kenkey have been confirmed by molecular methods to be *Saccharomyces cerevisiae* and *Candida krusei* (Hayford & Jakobsen, 1999; Hayford & Jespersen, 1999).

The presence of moulds during the initial stages of maize dough fermentation has also been reported (Jespersen et al., 1994). These moulds — *Penicillium*, *Aspergillus*, and *Fusarium* species, including potential mycotoxin producers — were isolated from raw maize, but during the maize dough fermentation the initial high counts disappeared within 24hr of fermentation.

3.3 Physico-chemical and sensory characteristics

Volatile compounds present in fermented maize dough to be used for kenkey production have been identified Annan et al. (2003) and are shown in table 1. Annan et al 2003 have also identified aroma compounds produced during spontaneous fermentation of maize dough for 48 h through GC sniffing and are shown in Table 2.

A complex combination of factors during steeping, milling and dough fermentation contribute to the final pasting characteristics of kenkey (Nche et al., 1996). Endogenous enzymatic activity, hydration and grain softening during soaking combine to facilitate the release of starch during milling, thus ensuring better hydration and swelling of granules, to achieve a high degree of gelatinization and set back viscosity necessary for good *aflata* quality. In kenkey production, the aflatalization (gelatinization) process is crucial for the texture of the kenkey and the gelatinization properties are described in terms of viscosity and studied by amylographic measurements (Hayford, 1998). A dough with a high starch gelatinization index (during cooking) and a high set back viscosity on cooling is required to give an *aflata* of adequate binding and moisturizing capacity important in determining the desired textural characteristics of cooked kenkey (Nche et al., 1996).

Amponsah (2010) has recently carried out an instrumental textural profile analysis of kenkey using a texture analyzer and reported the following scores for the different parameters; hardness, 3.85 ± 1.52; adhesiveness, -1.17 ± 0.91; springiness, 0.40± 0.07; cohesiveness, 0.23 ± 0.04; gumminess, 0.86 ± 0.35; chewiness, 0.36± 0.21; and resilience, 0.09 ± 0.02. Adhesiveness is the force required in removing materials that adhere or stick to the palates during the process of mastication; hardness value being the peak force of the first compression of the product; cohesiveness how well the product withstands a second deformation relative to how it behaved under the first deformation; springiness how well a product physically springs back after it has been deformed during the first compression; chewiness the length of time required to masticate a product at a constant rate of force application to reduce it to a consistency suitable for swallowing; gumminess the denseness of a product that persist through mastication, energy required to disintegrate a semi-solid food to a state ready for swallowing; and resilience how well a product recovers from deformation. From the correlation matrix of means obtained from the instrumental texture parameters compared with sensory evaluation by untrained panelists, cohesiveness and resilience showed significant positive correlation with sensory texture implying that when the panelists assessed the texture of *kenkey* they associated texture with how cohesive or resilient the product was.

3.4 Product quality perception/requirement by consumers

The requirement of kenkey by consumers may be attributed to several factors. To an extent it may be due to

- convenience, accessibility and affordability
- habit ("we have always eaten it and nothing has happened")
- psychological attitude i.e. resignation or fatalism of consumers ("there is nothing we can do about it anyway")
- the inability of consumers to associate safety of the food with its overall quality since many consumers may confuse taste with quality
- lack of alternatives or options
- poverty or budget constraints

Kenkey is consumed principally in the coastal areas. It is consumed as a main meal served with fried or grilled fish and an accompanying sauce or soup. The sauce is usually a blend of onions, tomatoes, pepper, and salt, which is freshly ground and uncooked. Kenkey forms an important article of diet in the food-eating habits of low income workers who may eat it as breakfast, lunch or dinner. Kenkey is a heavy meal because it is bulky, so when eaten as breakfast, it carries through to dinner thus making it economical (Halm et al., 2003).

Table 1. Volatile compounds identified in maize dough after 3 days of spontaneous fermentation. (Source Annan et al., 2003)

	Compound	Identification		
		Retention index	MS	Reference[a]
Carbonyls	3-methylbutanal	nd	*	X
	Diacetyl	930	*	X
	Pentanal	932	*	X
	Hexanal	1,068	**	X
	2-heptanone	1,175	**	X
	Heptanal	1,178	**	X
	1-octen-3-one	1,277	*	X
	Nonanal	1,382	**	X
	Furfural	1,394	*	X
	2-octenal	1,405	**	X
	Trans,trans-2,4-heptadienal	1,472	**	X
	Benzaldehyde	1,495	*	X
	2-nonenal	1,525	*	X
	Phenylacetaldehyde	1,607	**	X
	2-decenal	1,638	*	X
	2,4-nonadienal	1,683	*	X
	2-undecenal	1,738	*	X
	2,4-decadienal (*E,Z*)	1,744	*	X
	2,4-decadienal (*E,E*)	1,783	**	X
	γ-nonalactone	1,992	*	X
	Pentadecanal	2,132	*	X
Alcohols	Ethanol	914	**	X
	Propanol	1,016	**	X
	2-Methyl-1-propanol	1,085	*	X
	1-Butanol	1,130	*	X
	1-Penten-3-ol	1,143	*	X
	3-Methylbutanol	1,189	**	X
	3-Methyl-3-butenol	1,237	*	X
	1-Pentanol	1,243	**	X
	1-Hexanol	1,335	**	X
	1-Octen-3-ol	1,443	*	X
	1-Heptanol	1,449	*	X
	1-Octanol	1,549	*	X
	2-Undecenol	1,590	*	X
	Nonanol	1,656	*	X
	2-Nonen-1-ol	1,697	*	X
	Phenylethyl alcohol	1,893	**	
	2,4-Decadienol	1,964	*	
	Nerolidol	2,027	*	
Esters (C<12)	Ethyl acetate	nd	**	
	Ethyl propionate	921	(*)	
	3-Methylbutyl acetate	1,115	*	
	Ethyl hexanoate	1,231	*	
	Hexyl acetate	1,254	*	
	Ethyl lactate	1,301	*	
	Ethyl heptanoate	1,305	(*)	
	Ethyl octanoate	1,420	*	
Acids (C<12)	Acetic acid	1,422	**	
	Propanoic acid	1,514	*	
	Pentanoic acid	1,716	(*)	
	Hexanoic acid	1,804	*	
	Heptanoic acid	1,930	*	
	Octanoic acid	2,037	*	
	Nonanoic acid	2,144	(*)	
Furan, phenols	2-Pentyl furan	1,227	*	
	Guiacol	1,829	*	
	4-Vinylguiacol	2,153	*	
Other	3-Ethyl-2-methyl-1,3-hexadiene	1,387*		

[a] Known reference compound in close agreement with mass spectrum and retention index

Nd Not detectable, ** quality index >90, * quality index between 80 and 90, (*) quality index between 70 and 80, where quality index = degree of agreement between mass spectrum of sample and mass spectrum in database on a scale from 0 to 100

Table 2. GC sniffing identification of aroma compounds produced during spontaneous fermentation of maize dough for 48 h (Source Annan et al., 2003)

Compound	No. of judges[1]	Average intensity[2]	Odour description
Hexanoic acid	4	4.5	Strong, urine
Pentanoic acid	2	4.0	Burnt rubber
Ethyl hexanoate	2	3.5	Unripe pear, plant
Guaiacol	3	3.5	Chemical, hospital
Unidentified peak	2	3.5	Eraser, hospital
1-Octene-3-one	4	3.3	Mushrooms
Unidentified	3	3.0	Linseed oil, insecticide
Trans-2-octenal	4	3.0	Bad, peas, cucumber
Unidentified peak	3	3.0	Library, insecticide
Trans-2-undecenol	2	3.0	Mouldy, wet soil
Phenylacetaldehyde	3	3.0	Hyacinth, tulip, rose
Nonanol	4	3.0	Popcorn
No peak	3	3.0	Sour, spoiled fruit
2,4-Nonadienal	4	3.0	Fermented, deep frying
4-Vinylguiacol	3	3.0	Old, hospital, raw bacon
Acetic acid	3	2.7	Sour, vinegar
Ethyl propionate	3	2.5	Fruity, sweet
Nonanal	4	2.5	Aquarium, water
2-Nonenal	4	2.5	Old, musty, onions
Nerolidol	4	2.5	Dill, dried
Unidentified	3	2.1	synthetic, smelly
3-Methyl-butanal	3	2.0	Bread, sweet
Ethanol	2	2.0	Alcohol
1-Propanol	2	2.0	Alcoholic, fruity
Hexanal	4	2.0	Green, grass
Unidentified	2.	2.0	Fruity, candy
1-Penten-3-ol	1	2.0	Boiled potatoes
2-Heptanone	1	2.0	Bad
Heptanal	2	2.0	green
2-Pentyl-furan	3	2.0	Sweet, liquorice
No peak	4	2.0	Cooked food, meaty
Heptanol	1	2.0	Alcohol
Benzaldehyde	3	2.0	Vegetables, green
1-Octanol	2	2.0	Orange, sweet smell
2-Undecenal	4	2.0	Citrus, fruity
2,4-Decadienal	3	2.0	Chicken soup
Trans, trans-decadienal	4	2.0	Bacon, lemon, chips
Phenylethylethanol	3	2.0	Flowers
Octanoic acid	3	2.0	Urine
Heptadecane	2	2.0	Perfume
Pentadecanal	3	2.0	Sweet, spicy
2,4-Heptadienal	3	1.5	Hot, boiled potato
2-Methylpropan-1-ol	2	1.0	Pungent, rubber
1-Butanol	1	1.0	Sweet smell
Hexanol	2	1.0	Sweet, flower
3-Methylbutanol	2	0.5	vegetables

[1] Number of judges to detect odour
[2] Mean odour intensity perception recorded by judges (on a scale of 1 to 5 in increasing order)

4. Consumption forms of the product

4.1 Food forms

There are different types of kenkey. Some are sweetened with sugar, some have sweet potatoes or salt added. Some are wrapped in maize sheaves while others are wrapped in dried plantain leaves. Some are made from wholegrain maize flour and dark in colour, others are white and made from high extraction flour. The three common types of kenkey are the Fanti kenkey wrapped in plantain leaves, and Ga-kenkey and Nsiho or Akphorhe wrapped in corn husks (see Plates 8 & 9). The corn husk wrapping is typically pushed into the dumpling from below, leaving part of it exposed at the top. The further the corn husks are pushed into the bottom of the dumpling, the more ample its appearance (Muller & Nyarko-Mensah 1972).

There are numerous other types of *kenkey,* including a type where the skins of the corn are removed before grinding it. A sweet version is called *dokompa*, and it is one of the few instances where sugar is added to a main carbohydrate (sweet potatoes or yam are also added). *Kenkey* can also be made from plantains, where very ripe plantains are pounded and mixed with green plantain meal (*amada kokonte*). Plantain *kenkey* is known as *brodokono* in Twi, *afanku* in Ga, and *ahyenku* or *asenku* in Fanti (www.betumi.com).

Plate 8. Ga kenkey

Plate 9. Fanti kenkey

4.2 Period of the day for consumption (breakfast, lunch, dinner)

Kenkey forms an important article of diet in the food-eating habits of low-income workers who may eat it as breakfast, lunch or dinner. Kenkey is a heavy meal because it is bulky, so when eaten as breakfast, it provides a feeling of satiety to dinner thus making it economical. It may also be mashed with water into a thin porridge, a sort of refreshing drink to which sugar and milk are added (Halm et al., 2003).

5. Research activities and new development on technology and product

Several studies have been carried out to upgrade and mechanize some of the unit operations involved in the production of kenkey, including the development of shelf-stable dehydrated fermented maize meal flour as a convenience intermediary product.

Spontaneously fermented maize dough has been successfully dehydrated in a hot air tray dryer (Fig. 5) at temperatures of 60° C, 120°C, and 200° C to produce acceptable product (Andah & Osei-Yaw, 1979). Dehydration at a temperature range of 60–70° C did not affect total acid content of the product, and taste panel evaluations found products such as *akasa*, *koko*, and *banku* made from the dehydrated dough acceptable. Dehydrated fermented maize meal made by this method can be reconstituted into fresh dough by adding water and is now produced on commercial basis for sale in Ghana and also for export.

An accelerated option for industrial production of kenkey flour was developed by inoculating dry-milled maize flour with dough containing an enrichment of lactic acid bacteria to accomplish fermentation within 24 h of incubation at 30° C to obtain the required level of acidification (Nche et al., 1994). Subsequently, the dough was dehydrated into kenkey flour and pre-gelatinized *aflata* using cabinet and drum drying. Although the two methods were effective in preparation of pre-gelatinized *aflata*, drum drying caused a 34% reduction in titratable acidity of the fermented dough whereas cabinet drying had a less drastic effect. The possibility of using a mixture of drum-dried *aflata* and uncooked cabinet dried flour for convenient preparation of kenkey at domestic level was demonstrated. However, dry-milled maize flour had inferior pasting and setback viscosities as compared to the traditionally prepared dough and was not suitable for the production of pre-gelatinized starter dough.

The cooking time and energy expenditure was reduced from 2 hr to 35 min by changing the dimensions of the kenkey balls from 10–15 cm diameter to 6 cm diameter cylinders. Due to the different processing conditions, yeasts were found to be more active than in traditional fermentation, resulting in higher alcohol levels. However, these alcohol levels remained low and ethanol disappeared after cooking. The combination of lactic acid fermentation and cooking resulted in a microbiologically stable product even after the dumpling had been deliberately contaminated. This study concluded that the traditional kenkey-making process could be shortened to 24 hr by a combination of reduced steeping time, use of starter dough in a dough-*aflata* mixture, and packaging in sausage casings. However, it should be noted that the traditional packaging of kenkey in maize husks or plantain leaves gives it a unique sensory characteristic that consumers associate with the product.

Attempts have also been made to increase the protein content of kenkey by fortification of the dough with amino acids, soybeans (Plahar et al., 1983; Plahar et al., 1997), cowpeas (Nche et al., 1994b) and also by the development of Quality Protein Maize (QPM) varieties (Eyeson & Ankrah 1975; Ahenkora et al., 1995). In addition to increasing the protein content, addition of boiled whole soybeans to soaked maize before milling and fermentation reduced the fermentation time by 60% (Plahar et al., 1997). A lactic acid bacteria–enriched starter dough has been developed by back-slopping. Initially, a previous batch of acceptable-quality spontaneous fermented dough was used to inoculate fresh dough at a level of 10%. The procedure was repeated every 24 h at 30◦C until a stable culture indicated by pH, titratable acidity, and viable microbial numbers was obtained. This was then used successfully to ferment dough within 24 h at 30◦C to the required level of acidification, a total titratable acidity value of 1.24%, calculated as lactic acid on a wet weight basis, and a pH of 3.79 (Nche et al., 1994b).

A starter culture containing strains of *L. fermentum*, *S. cerevisiae*, and *C. krusei* has also been developed for the production of fermented maize dough. Both in laboratory trials and at a commercial production site, the period of fermentation could be reduced from 48–72 h to 24 h. The organoloeptic qualities of the kenkey and *koko* prepared from doughs fermented with the starter for 48 h were not significantly different from the traditional products. However, kenkey prepared from doughs fermented for 24 h with starter culture were found to be unacceptable by the taste panel although similarly produced koko was acceptable (Krogbeck, 1993; Halm et al., 1996; Amoa-Awua 1996; Hayford 1998).

At the Food Research Institute of the Council for Scientific and Industrial Research, Ghana, a pilot plant has been established for semi-industrial scale production of dehydrated fermented maize meal and kenkey using modern methods of food processing. The plant layout satisfies the basic elements of Good Manufacturing Practice, whilst the cleaning of maize is mechanized. The maize is steeped in tanks line with porcelain tiles, and dough fermented in small plastic containers. The kenkey is cooked in a small retort and dough dehydrated in a walk in cabinet dryer (Amoa-Awua et al., 1998)

An HACCP system that is suitable for kenkey production at both traditional and upgraded commercial production sites has been published as a manual and been used to train processors, entrepreneurs, etc (Amoa Awua et al., 1998). A semi-commercial kenkey production plant in Accra was also upgraded by the Food Research Institute and HACCP implemented at the plant in 1997 (Amoa-Awua et al., 2007). The HACCP Plan developed by Amoa-Awua et al (1998) is presented in table 2.

Conclusion (Perspectives on research and innovation needs)

Kenkey is one of the best examples of traditional African foods, which through history have played a significant role in food safety as well as food security. The underlying fermentation process has provided foods of highly appreciated properties and represented an art of food preparation and preservation with substantial socio-economic impact in West African societies. The raw materials used are all of local origin and the sustainability of this type of food processing is unique. The industrialization of the global agribusiness system has strongly concentrated opportunities for adding value to the process end of the chain. Development of traditional food fermentations, like processing of kenkey, into scientifically based and controlled industrial operations will be a way forward for the food industry in Ghana and beyond.

Through recent intensive research activities, the microbiology of kenkey is now very well understood. Effective starter cultures have been identified and shown to improve maize fermentations leading to the preferred characteristics of kenkey. The cultures appear to have desired functional properties and they have been defined by detailed pheno- and genotyping, which can also provide a proper background for patenting of cultures and protecting intellectual rights. It has been demonstrated how traditional production sites can be upgraded to meet the requirements of recognized guidelines of GMP. Local producers, consultants, and organizations have been trained in the use of the HACCP concept for management of food safety in maize processing. Kenkey flour with an extended shelf life has been developed.

The final step of development, to achieve a product that is acceptable and attractive to the international market and European consumers, in particular seems no longer to be out of reach. This is the activity to be tackled by the African Food Traditional Revisited by Research project. The next move should be directed towards the development of local governmental agencies for independent and qualified verification and validation of the safety and quality of kenkey as well as hygienic conduct and understanding of the basic principles of food hygiene in the complete chain from growing and handling of maize through to the processing of kenkey. The important role of microbiology in African foods has been demonstrated by the biodiversity and promising properties of the dominating microorganisms in the many different fermented foods, including kenkey, in Africa. It justifies that microbiology be made a high-priority research area in Africa to support development in biotechnology. Potential biotechnological activities could include, for example, production and sales of starter cultures, probiotic cultures, cultures for bio-preservation and bioactive substances for various purposes.

Table 2. HACCP Plan for kenkey production (Amoa-Awua et al., 1998)

		PROCEDURES			
DATE: June 2, 1995		PAGE	1 of 2	**APPROVED BY**	
		CONTROL OF CCP'S			
PROCESS STEP	HAZARD	CONTROL MEASURE	CRITICAL LIMITS	MONITORING PROCEDURE (each batch)	CORRECTIVE ACTION
MAIZE CCP	. Mycotoxins: Aflatoxins Citrinin fumonisins . Foreign materials	.Purchase good quality material	> .... ppm 13.0% moisture > .... ppm	. Visual inspection	. Reject raw material and inform supplier
STEEPING CCP	. Spoilage and pathogenic microorganisms	. Clean water . pH control to desired level . keep hands off	. Transparent, clear, odourless and colourless . pH 4.2+ 0.1 . Keep hands off	. Visual inspection . Use of pH strips	. Boil water . Educate . Steep longer
DOUGH FERMENTATION CCP	. Mycotoxins . Spoilage and pathogenic microorganisms	. Adherence to fermentation time . Cover dough	. pH not > 3.9 . Titrable acidity Lactic: -1.4-2% Acetic:0.18-023% . Volatile/Non volatile acid ratio about 0.16	. Visual inspection . Use of pH strips	. If fermentation is slow backslop with old dough

PROCEDURE					
DATE: June 2, 1995	PAGE 2 of 2	APPROVED BY:			
PROCESS CONTROL					
PROCESS STEP	HAZARD	CONTROL MEASURE	CRITICAL LIMITS	MONITORING PROCEDURE	CORRECTIVE ACTION
PACKAGING CCP	. Mycotoxins in maize husks	. Selection of non- mouldy maize husks . Good Hygiene	>.......ppm . free from moulds	. Visual inspection	. Reject
. COOKING CCP	. Residual mycotoxins in kenkey: Aflatoxins Citrinin	. Adequate cooking	. not less than 3 hrs cooking > 10 parts per bilion of aflatoxins	. Recording of time	. Heat longer
KENKEY Final product			>100 cfu/g of foreign bacteria (non LAB) >100 cfu/g of moulds >10 parts per billion of aflatoxins		
CLEANING CCP	. Contamination with spoilage and pathogenic microorganisms	. Good housekeeping and personal hygiene . Maintenance of equipment	. Clean premises, processing equipment and vessels and processing staff	. Visual inspection	. Clean premise, hall equipment and vessels . Clean factory coats . Wash hands . Use gloves

REFERENCES

African foods- African Traditional foods in the UK (http://www.africanfoods.co.uk/buy-ga-kenkey.html).

Ahenkora, K., Twumasi-Afriyie, S. Haag, W. & Dzah, B.D. 1995. Ghanaian kenkey from normal and quality protein maize: comparative chemical composition and rat growth trials. *Cereal Research Communications*. 23:299–304.

Akingbala, J.O., Onochie, E.U., Adeyemi, I. A., & Oguntimein, G. B. 1987. Steeping of whole and dry-milled maize kernals in Ogi preparation. *Journal of Food Processing and Preservation*. 11, 1-11.

Allotey, L.D. 1996. Trends and developments in kenkey production in Ghana. Food Research Institute, Accra, Ghana.

Amoa-Awua, W.K. A. 1996. Commercial production of kenkey using *Lactobacillus fermentum* as starter culture for fermentation of maize. Food Research Institute Council for Scientific and Industrial Research, Accra, Ghana.

Amoa-Awua, W.K. A., Halm, M. & Jakobsen, M. 1998. HACCP System for Traditional African Fermented Foods: Kenkey. World Association of Industrial and Technological Research Organizations (WAITRO)Taastrup, Denmark.

Amoa-Awua, W.K., Ngunjiri, P., Anlobe, J., Kpodo, K. & Halm, M. 2007. The effect of applying GMP and HACCP to traditional food processing at a semi-commercial kenkey production plant in Ghana. *Food Control*, 18, 1449-1457.

Amponsah, A.K. 2010. The Ga-Kenkey production process – investigating opportunities for waste water reuse and identification of sources of product quality variability. M.Phil thesis, University of Ghana.

Andah, A. & Muller, H.G. 1973. Studies on koko,a Ghanaian fermented maize porridge. *Ghana J. Agric Sci.* 6:103–108.

Andah, A. & Osei-Yaw, A. 1979. Dehydrated fermented maize dough. Food Research Institute Bulletin. Ghana.

Ankrah, E.K. 1972. Riboflavin content of some fermented foods of Ghana. *J Agric Sci*. 5:95–98.

Annan, N.T. 2002. Aroma characteristics in Ghanaian maize dough fermentations. PhD thesis University of Ghana/ Royal Veterinary and Agricultural University, Denmark.

Annan, N.T., Poll, L., Plahar, W.A. & Jakobsen, M. 2003. Aroma characteristics of spontaneously fermented Ghanaian maize dough for kenkey. *European Food Research Technology*, 217, 53-60.

Annan-Prah, A. & Agyeman, J. A. 1997. Nutrient content and survival of selected pathogenic bacteria in kenkey used as a weaning food in Ghana. *Acta Tropica.* 65:33–42.

Atople, R. 2006. The assessment of microbial quality of fanti kenkey in different packages. HND dissertation. Accra Polytechnic, Accra, Ghana

Bediako –Amoa, B. &Muller, H.G. 1976. Studies on Kenkey with particular references to calcium and phytic acid. *Cereal Chemistry* 53, 365-375.

Christian, W.F. K 1970. Lactic acid bacteria in fermenting maize dough. *Ghana J. Sci*. 10:22–28.

Davey, P.L. H. 1962. Report on the National Nutrition Survey, Accra: National Food and Nutrition Survey. (Mimeo), 63 pp.

Dovlo, F. 1970. Maize in the Ghanaian diet. Food Research Institute Bulletin, Ghana.

Eyeson, K.K. & Ankrah, E. K. 1975. Composition of food commonly used in Ghana. Food Research Institute, Ghana. Fields, M.L., Hammed, A.M. & Smith, D.K 1981. Natural lactic fermentation of corn meal. *J Food Sci*. 46:900–902.

Halm, M., Amoa-Awua , W. K. & Jakobsen, M. 2003. Kenkey, an African Fermented Maize Product. In: Handbook on fermented foods and beverage science and technology. Edited by Hui, Y. H., Lisbeth Meunier-Goddik , Åse Solvejg Hansen , Jytte Josephsen , Wai-Kit Nip , Peggy S. Stanfield , and Fidel Toldra Marcel Dekker, New York, Pp. 799-818.

Halm, M ., Lillie, A., Sørensen, A.K. & Jakobsen, M. 1993. Microbiological and aromatic characteristics of fermented maize doughs for kenkey production in Ghana. *Int. J Food Microbiol*. 19:135– 144.

Halm, M., Osei-Yaw, A., Kpodo, K. A., Amoa-Awua, W.K.A. & Hayford, A. 1996. Experiences with the use of starter culture in the fermentation of maize for kenkey production in Ghana. *World J Microbiol Biotechnol.* 12:531–536.

Halm, M., Hornbæk, T., Arneborg, N., Sefa-Dedeh, S. & Jespersen, L. 2004. Lactic acid tolerance determined by measuring of intracellular pH of single cells of *Candida krusei* and *Saccharomyces cerevisiae* isolated from fermented maize dough. *International Journal of Food Microbiology*, 94, 97-103.

Halm, M. 2006. Microbial growth responses in fermenting maize dough systems. Ph.D thesis. University of Ghana/ Royal Veterinary and Agricultural University, Denmark.

Hamaker, B.R., Kirleis, A.W., Butler, L. G., Axtell, J.D. & Mertz, E. T. 1987. Improving the in vitro protein digestibility of sorghum with reducing agents. *Proceedings of the National Academy of Sciences of the United States of America* 84:626–628.

Hayford, A. E. 1998. Characterization of the dominant microbiota of Ghanaian maize fermentation (kenkey). PhD thesis. The Royal Veterinary and Agricultural University Denmark, Department of Dairy and Food Science.

Hayford, A. E. & Jakobsen, M. 1999. Characterization of *Candida krusei* strains from spontaneously fermented maize dough by profiles of assimilation, chromosome profile, polymerase chain reaction and restriction endonuclease analysis. *J Appl. Microbiol*. 87:29–40.

Hayford, A.E. & Jespersen, L. 1999. Characterization of *Saccharomyces cerevisiae* strains from spontaneously fermented maize dough by profiles of assimilation, chromosome polymorphism, PCR and MAL genotyping. *J Appl. Microbiol*. 86:284–294.

Hayford, A.E., Petersen, A., Vogensen, F.K. & Jakobsen, M. 1999. Use of Conserved Randomly Amplified Polymorphic DNA (RAPD) Fragments and RAPD Pattern for Characterization of *Lactobacillus fermentumin* Ghanaian Fermented Maize Dough. *Appl. Environ Microbiol.* 65:3213–3221.

Holzapfel. W. 1997. Use of starter cultures in fermentation on a household scale. *Food Control.* 8:241–258.

Jespersen, L., Halm, M., Kpodo, K. & Jakobsen, M. 1994. Significance of yeasts and moulds occurring in maize dough fermentation for 'Kenkey' production. *Int. J Food Microbiol.* 24:239–248.

Johnson, P.N.T. & Halm, M. 1998. Maize quality requirements of producers of six traditional Ghanaian maize products. *Ghana J. Agric. Sci*. 31:203-209.

Khetarpaul, N. & Chauhan, B.M. 1989. Effect of fermentation by pure cultures of yeasts and lactobacilli on phytic acid and polyphenol content of pearl millet. *J Food Sci*. 54:780–781.

Kpodo, K., Sørensen, A. K. & Jakobsen, M. 1996. The occurrence of mycotoxins in fermented maize products. *Food Chem* 56:147–153.

Kpodo, K., Thrane, U. & Hald, B. 2000. Fusaria and fumonisins in maize from Ghana and their occurrence with aflatoxins. *International Journal of Food microbiology*, 61,147-157.

Kpodo, K. 2000. Fumonisins n Ghanaian maize. Ph.D thesis. University of Ghana/ Royal Veterinary and Agricultural University, Denmark.

Krogbeck, K.W. 1993. The use of starter cultures for fermentation of Ghanaian maize dough. MSc. Project dissertation, Royal Veterinary and Agricultural University, Denmark.

Lartey, B. L., 1975. Some technological transformation and research needs in Ghana's indigenous food industries. UNIDO Joint Consultation on Promotion of Industrial Research and Services in Africa. Lagos 15-22 September 1975. UNIDO.

Mensah, P., Tomkins, A. M., Drasar, B. S. & Harrison. T.J. 1991. Antimicrobial effect of fermented Ghanaian maize dough. *J Appl. Bacteriol.* 70:203–210.

Mertz, E.T. 1970. Nutritive value of corn and its products. GE Inget (Ed). Avi Publishing Co., West-port, CT. pp 350.

Muller, H.G., & Nyarko-Mensah, B. 1972. Studies on Kenkey, a Ghanaian cereal food. *J. Sci. Food Agric.* 23, 544-545

Nche, P.F., Nout, M.J.R. & Rombouts, F.M. 1994a. The effect of cowpea supplementation on the quality of kenkey, a traditional Ghanaian fermented maize food. *J Cereal Sci.* 19:191–197.

Nche, P. F., Odamtten, G.T., Nout, M.J.R. & Rombouts, F. M. 1994b. Dry milling and accelerated fermentation of maize for industrial production of kenkey a Ghanaian cereal food. *J Cereal Sci.* 20:

291–298.

Nche, P.F., Nout, M.J.R. &Rombouts, F.M. 1995. The effects of processing on the availability of lysine in kenkey, a Ghanaian fermented maize food. *Int J Food Sci Nutr*. 46:241–246. Nche, P.F.,

Odamtten, G. T., Nout, M.J.R. & Rombouts, F.M. 1996. Soaking of maize determines the quality of aflata for kenkey production. *J Cereal Sci* 24:291–297.

Nout, M.J.R., Kok, B., Vela, E., Nche, P.F. & Rombouts, F.M. 1996. Acceleration of the fermentation of kenkey, an indigenous fermented maize food of Ghana. *Food Res Int* 28:599–604.

Obiri-Danso, K ., Ellis, W. O., Simpson, B. K. & Smith, J. P. 1997. Suitability of high lysine maize, *Obatanpa* for kenkey production. *Food Control*. 8:125–129.

Olasupo, N.A, Olukoya, D.K. & Odunfa, S.A . 1997. Identification of Lactobacillus species associated with selected fermented African foods.*Verlagder Zeitschrift fur Naturforchung*. 105–108.

Plahar, W. A. & Leung, K. 1982. Effect of moisture content on development of carboxilic acids in traditional maize dough fermentation. *J Sci Agric* 33:555–558.

Plahar, W.A., Leung, H.K. & Coon, C. N. 1983. Effects of dehydration and soy fortification on physico- chemical, nutritional and sensory properties of Ghanaian fermented maize meal. *J Food Sci.* 48:1255–1259.

Plahar, W.A., Nti, C.A. & Annan N.T. 1997. Effect of soy fortification method on the fermentation char- acteristics and nutritional quality of fermented maize meal*. Plant Foods for Human Nutrition.* 51:365–380.

Sefa-Dedeh, S. & Plange, H. 1989. Processing of Ga Kenkey (*komi*) in Greater Accra region. A techno- economic study. Kellogg International Report 03/1988 1–36.

Sefa-Dedeh, S. 1993. Traditional food technology. In Encyclopaedia of Foods, Food Technology and Nutrition, ed Macrae, R., Robinson , F. & Sadler, M. 4600-4606. New York : Academic Press.

The African Culinary Network (www.betumi.com)

Tomlins, K. & Johnson, P.N. T. 2004. Developing food safety strategies and procedures through reduction of food hazards in street-vended foods to improve food security for consumers, street food vendors and input suppliers. Crop Post Harvest Programme (CPHP) Project R8270. Funded by the DFID.

Tortoe, C., Johnson, P-N. T. & Ottah Atikpo, M. 2008. Modules for managing street food/informal vending in Ghana. DFID/CPHP/NRI/CSIR-FRI PROJECT CONTRACT NO. R8433 (ZB0375).

Whitby, P. (1968). Foods of Ghana. Food Research Institute Bulletin, Ghana.

Yartey, J., Harisson, E.K., Brakohiapa, L.A ., Troph, D.O. & Nkrumah, F.K 1993. Carbohydrate and electro lyte content of some home-available fluids used for oral re-hydration in Ghana. *J Trop Paed*. 39:234–237.

Literature review and Background information
of
Kishk Sa'eedi

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:

Ahmed, Z.S. and Hassan-Wassef, H

NRC (Egypt)

December 2010

Table of contents

ABSTRACT

The Egyptian indigenous cereal-based fermented food called *Kishk Sa'eedi* (KS) is reviewed in this report which describes the traditional origins as well as the evolution that occurred across time resulting in modifications that involved significant scientific and/or technological steps. Fermented cereal-based foods such as *Kishk Sa'eedi* (KS) have received limited attention by researchers. *Kishk Sa'eedi* is an indigenous food that is part of the rich food heritage of Egypt. Various products derived from fermented milk, with or without the addition of wheat (or other cereals), are common to the Eastern Mediterranean and Arab countries, including Turkey and Iran. The present review differentiates between the ingredients and methods used in the production of the Egyptian KS and the kishk produced in Lebanon. Several of these fermented milk products are known by other names, and the appellation "kishk" may refer to a fermented product that may not even contain wheat as is the case for the Iranian fermented milk paste called "Kishk". The milk-cereal mix in KS provides a source of affordable balanced proteins that are particularly valuable for children and can be promoted as a high quality locally produced component in nutrition improvement and poverty alleviation programmes. The first step towards valorization and protection of such indigenous fermented foods involves scientific characterization of the product that includes investigating the production methods and processing techniques, and establishing standards for their operating procedures. .

The present review focuses primarily on the indigenous cereal-based fermented *Kishk Sa'eedi* (KS) that will be subjected – for the first time - to a full scientific investigation in the present AFTER Project. The results will provide new knowledge about KS. KS research is rarely encountered in published literature and the locally produced grey literature dating as early as the mid-20th Century was undermined by the limitations of the available technical plateau during that period. Also no verification had ever been undertaken of its potential health attributes.

INTRODUCTION

Fermented milk–wheat mixtures, known as *kishk* in the Middle East and *tarhana* in Greece and Turkey, are important foods in the diet of many populations. In addition to their well-established position in the dietary patterns of the people in the above countries, these products have even been promoted in Mexico (Cadena & Robinson, 1979) and in Europe (Tamime et al, 1995). The name *"Kishk"* refers to a group of popular fermented dairy-cereal mix products and their variations. According to Tamime (1995) there are three main kinds of food referred to as "*"Kishk"*. They include foods based on curdled milk products like yoghurt or fresh cheese; foods based on barley broth, bread, or flour; and foods based on cereals combined with curdled milk. In the Turkish and Greek cuisine, the closely related foods are called *tarhana* or *trahana*.

Throughout a region that extends from the Eastern Mediterranean to Iran in the Indian subcontinent, the name *Kishk* is applied to a number of dried fermented milk products. Thus, it is extremely difficult to find a common definition for *Kishk* which adequately covers all these products. In the present AFTER Project, the traditional name *Kishk Sa'eedi* (KS) is reserved for the Egyptian product prepared traditionally according to the method applied by Upper Egyptians. The term *Sa'eedi* is the designation that is given to the people of the *Sa'eed* or the south of Egypt.

The cereal-based fermented food *Kishk Sa'eedi* (KS) constitutes a major source of high quality dietary nutrients for millions of Egyptian. It is a basic traditional food for Upper Egyptians and is popular among all social strata. To-date, KS has not been fully investigated and standards for its operating procedures have never been established. Published literature on KS is scanty, and the locally produced grey literature that dates back to the 1950's was limited by the state of the art of the technical plateau of that period. No verification was made of its health attributes and claim for probiotic activity. Various products derived from fermented milk, with or without the addition of wheat or other cereals, are common to the Levant and Arab countries, and are even found in Iran. The majority of these fermented milk products are known by other names, such as *Guameed* in Jordan. The Lebanese, Turkish, and Iranian products that bear the name *"Kishk*" are all prepared using ingredients and methods that differ from the age-old method of the Egyptian *Kishk Sa'eedi*.

1. TRADITIONAL PROCESSING OF *KISHK SA'EEDI* (KS)

The traditional processing of *kishk* has been the subject of review by van Veen & Steinkraus (1970); Hesseltine (1979); Wang & Hesseltine (198 l); Steinkraus (1983); El-Gendy (1983, 1986) Tamime, and O'Connor 1995; and Jandal (l989) and recently by Blandino et al (2003) but limited information is available on the traditional Egyptian product that is under study, the *Kishk Sa'eedi* (KS). The following section draws in greater part on data from an unpublished article reporting on the findings of repeated field observations on KS production in Upper Egypt. ("The production of Kishk Sa'eedi in Egypt", by Ahmed ZS and Hassan-Wassef H, under preparation for publication).

The production of KS is commonly home based and the know-how is transmitted from mother to daughter. It is produced on a small scale in homes and in villages. *Kishk Sa'eedi* (KS) is typically prepared by mixing *Laban Zeer* (buttermilk separated from freshly drawn milk and left to sour in an unglazed earthenware container: the "*zeer*") with coarsely ground parboiled wheat. The locally grown mature freshly harvested whole wheat is boiled in a metal barrel on an open fire until soft then sun dried, milled (coarse) and sieved in the *ghorbal* in order to remove the finely ground part of the wheat meal. The concentrated *Laban Zeer* that is fermented for at least 40 days is mixed with the moistened coarsely ground parboiled wheat in a large earthenware *magour,* to produce a heavy paste called "*hama*". The milk cereal mixture is then allowed to ferment again for about 24 hours after which it is kneaded with the addition of more of the fermented salted milk diluted with a little water to reach the required consistency. Alternatively, the fermentation of the *hama* allowed to continue for a further 24 hours. The resultant mass is thoroughly mixed incorporating the aromatic spices before cutting into unformed chunks (of about 3 cm in diameter) or shaped into small balls of about 2 cm in diameter, which are arranged on a reed mat to dry in the sun. The product is stored in the form of the dried product.

Considerable product variations exist between KS and other varieties bearing the name *kishk.* For instance the Lebanese *kishk* is produced traditionally from goat milk and its commercial production method (Tamime and O'Connor 1995) is described as follows: Milk is boiled, cooled and fermented using a starter culture or the previous day's yoghurt. The ratio of bulgur to yoghurt is 1 : 4, and salt is added at a level of 6% (w/v). The yoghurt is added to the bulgur in small quantities for up to 6 days, and the mixture is kneaded daily. The temperature is maintained at 35°C in order to complete the fermentation and achieve proper hydration of the bulgur. Afterwards, the fermented milk-cereal mixture is formed into small balls, placed on trays or on the concrete floor of roofs and dried in the sun for 7-8 days. The sun dried *Kishk* is then milled to a powder at a flour mill and either packed in cloth, plastic bags or in large tins.

Table (1): Comparison between *Kishk Sa'eedi* (KS) and Lebanese *Kisk* (LK) preparation method:

	Kishk Sa'eedi (KS)	Lebanese *Kishk* (LK)
Ingredients and preparation		
Parboiling period (1 hr)		✓
Parboiling period (~4 hr)	✓	
Drain and dry after boiling	✓	✓
Coarse grind the parboiled wheat then winnow to remove bran (to produce bulgur*)		✓
Coarse grind boiled whole wheat and sift to remove fine part (higher rate of extraction)	✓	
Use of alternate cereal base		✓
Low fat yoghurt		✓
Strained yoghurt (labneh)		✓
Fermented concentrated buttermilk paste *(Laban Zeer)*	✓	
Aromatic spices (whole cumin seeds)	✓	
Process		
Mixing coarsely ground wheat with dairy base	✓	✓
The mixture is then kneaded daily for up to 6 times to complete the conditioning' period		✓
The mixture is left to rest overnight then kneaded into dough	✓	
Dough cut up into unformed chunks or rounded into balls	✓	✓
Chunks or balls are preserved in olive oil or crushed to a powder		✓

*Bulgur (coarsely ground and bran-free parboiled wheat)

1.1. Raw materials and additives used and their handling

The KS consists of two main ingredients namely: whole parboiled locally grown freshly harvested wheat and unpasteurized fermented buttermilk *(Laban Zeer)*.

The fermented buttermilk or *Laban Zeer* is prepared by collecting the buttermilk after churning raw unpasteurized buffalo or cow milk. In other words, it is a by-product of butter production. Traditionally, churning takes place in an animal skin bag called *kerbah*. It is usually that of a goat or sheep with the openings in the skin tied up. The churning is achieved by hanging the *kerbah* filled with milk from a wooden tripod or from the ceiling and vigorously shaking it back and forth until butter lumps are formed. Nowadays, the traditional churning is being replaced by the use of an electrically powered device (i.e. such as a small washing machine) to save time and reduces the physical effort of manual churning.

The collected buttermilk is transferred into an earthenware jar called *zeer,* and freshly separated butter milk is added to it each morning and stirred in, followed by a sprinkle of coarse table salt on the surface. The cover is then well secured with a clean cloth and the *zeer* is left in a well aired dark place. The whey formed by the process of fermentation and souring of the buttermilk progressively seeps through the pores of the unglazed jar and is collected and disposed of. Over time, the fermented buttermilk in the jar thickens to produce the sour milk referred to as *Laban Zeer* which is in the form of a heavy paste. This process of *Laban Zeer* production is seasonal and starts usually during December and January and can extend to April-May. During this period, the animals feed on fresh green clover which influences the composition and characteristics of the milk that is used in *kishk* production.

Whole Wheat

The wheat grains are manually sorted to discard stalks, dirt and weeds. Clean mature grains are boiled on an open fire in a metal barrel in plenty of water till they soften. The end point is just before rupture of the bran layer. They are drained and spread on mats to dry in the sun. They are then coarse milled and the resulting wheat meal is sieved using a metal mesh sieve or a *ghorbal*. The sieving process separates the finely ground wheat meal from the coarsely ground part. It is the latter that is preferably used in the production of KS.

Condiments

Whole cumin seeds are added just before cutting and shaping the fermented *hama*. In some households, a small quantity of finely ground hot chili pepper is added as well.

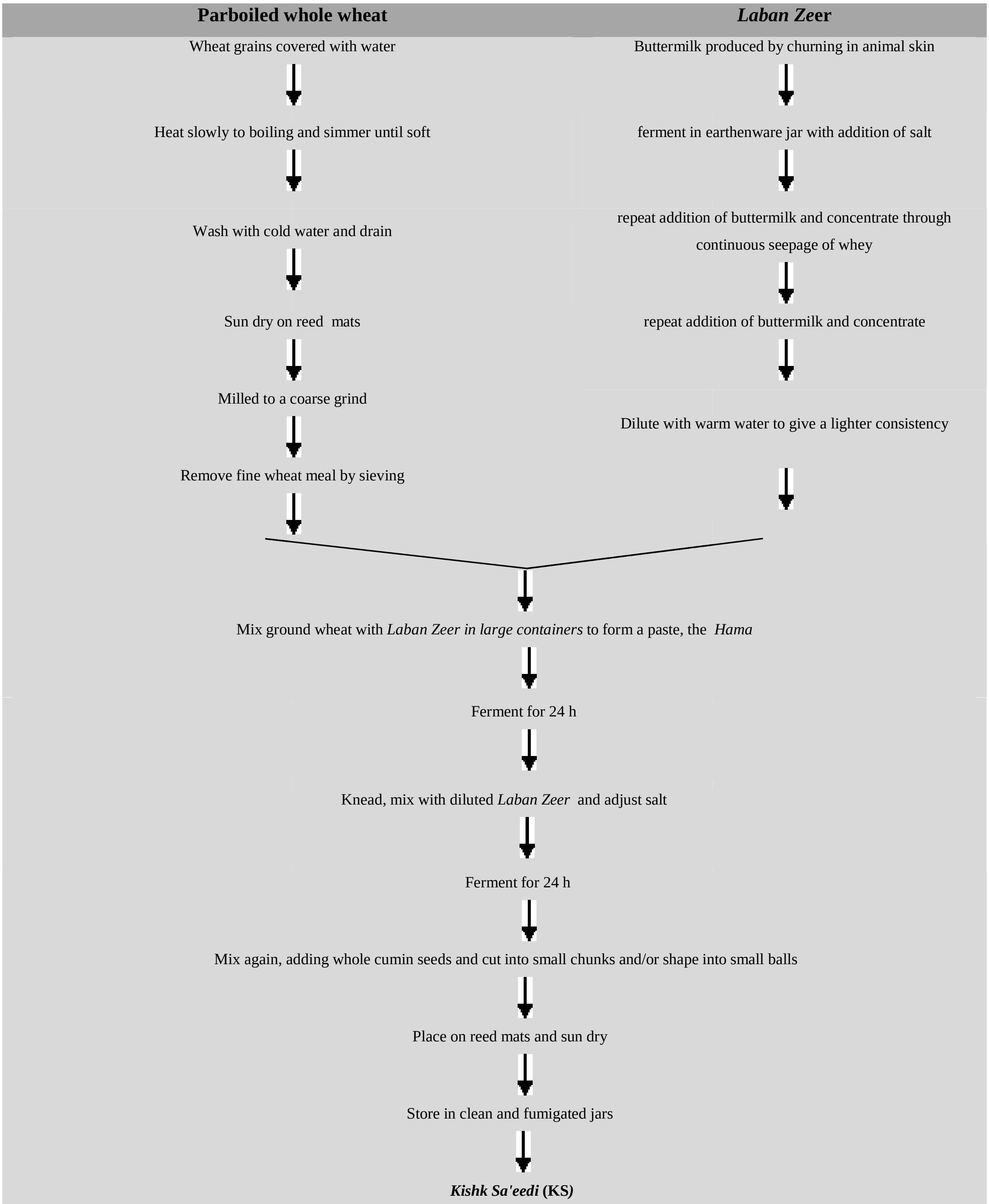
1.2. Description and variability/similarity of processing methods (with flow diagrams, equipments and promising technology)

The ingredients that enter into the production process include freshly harvested locally grown wheat, freshly separated butter milk from Egyptian cows or water buffalo, salt and cumin seeds. The milk is fermented alone, then mixed and fermented again with the coarsely ground mature whole wheat that had been previously parboiled and sun dried. The mixing is traditionally done in a large unglazed earthenware pot, the *magour,* in which the fermented milk and parboiled wheat mixture is left to ferment. Following completion of the second milk-wheat fermentation, the mixture is well kneaded and the cumin seeds added before cutting into small chunks and shaping into balls (or leaving to dry as small chunks) that are then spread out on reed mats to dry in direct sunlight or the hot shade.

The dry KS is stored in elongated mud-sealed unglazed earthenware jars (about a meter in height) that are stacked on the roof tops in direct exposure to the sun. Other smaller and more rounded earthenware containers called *Soma'a* (a reduced version of the traditional grain storage silo) can also be used for storage. Prior cleaning and fumigation of the jars destined for KS storage is common practice. Special plant materials, including grass, shrubs and hardwoods, are used for fumigation. The burning fumigation mixture is introduced into the storage container and kept inside for a few minutes with the lid closed. The containers are then allowed to cool and are wiped clean with a dry cloth specifically used for this purpose. In some regions the fumigation mixture includes hot red peppers. KS is considered shelf stable as it can be stored without depreciation or spoilage for up to the next *kishk* making season, that is, a shelf life of one year.

The methods employed for the production of Egyptian *Kishk Sa'eedi* (KS) may differ from one region to another because these processes are based on traditional local knowledge systems. One of the variations in KS is the milk-free *kishk* that is eaten during the fasting months for the Copts, the Egyptian Christians (El-Gendy, 1983).

Figure (1): Flow diagram for the preparation of *Kishk Sa'eedi* (KS)



1.3. Major problems associated with processing methods

The inconsistency in the sensory profiling as well as the hygienic quality of traditional KS available in the marketplace reflects the variability of its micro-flora and technological processes. Various contaminants have the potential to be invariably introduced during the processing stages. The standard of hygiene adopted by the KS operatives, the potable quality of the water and the cleanliness of the utensils used are the possible sources of contamination (Ahmed ZS personal communication 2004).

1.4. Storage methods, maximum duration and problems associated with storage

The shelf life of well dried KS balls stored in the traditional way reported above is one year. The growth of spoilage organisms is discouraged by some of the traditional methods used by women such as the incorporation of whole cumin in the final stage before shaping and sun drying. In addition to the fumigation of the earthenware containers used for storage, the cumin acts as an antimicrobial agent that prolongs the shelf life of the KS.

2. SOCIO-ECONOMIC IMPORTANCE

2.1. Production, processing, handling and storage zones identified in the country

The geographic region for traditional KS production extends south of Cairo from Fayoum to Luxor governorates. Though consumed all over the country, KS has not till now entered the food retail system.

2.2. Socio-economic profile of the actors (processors and retailers)

This technology is indigenous and is a product of the traditional culinary culture of the people. KS is produced by home based production units in rural families of the south. The know-how for preparation of KS is handed down from mother to daughter across generations. The traditional production method has been preserved with little change in the utensils and other equipment used, many of which such as the *zeer, the ghorbal or the magour* are modern reproductions of those found in the Egyptian museums. KS is essentially produced in rural areas south of the Nile delta for home and local consumption and is occasionally marketed. However, KS may reach some urban markets through informal marketing channels.

2.3. Socio-economic importance of the product (volume, employment generation, income, food security, etc...)

KS is the undisputed national food of Upper Egyptians where it shares the importance of bread as a basic component of the diet. It is considered essential for an Upper Egyptian home to always be well stocked in bread (dried) and *kishk*. The contribution of KS production to the household economy and food security in Upper Egyptian families is undeniable despite the non-conformity to official regulatory standards and the informal marketing and distribution channels (e.g. street vending, village weekly markets, neighbors, friends and family). Its importance to food security lies in the fact that it is a locally produced source of quality proteins that allows the consumption of milk proteins throughout the year. Such a contribution is crucial in rural areas where farming is one of the main economic activities and the resulting agrifood products are either consumed *in situ* or sold in neighboring urban or peri-urban markets. The income thus generated allows the family to pay for their other needs. KS production is a family business and is essentially a feminine occupation. In some households, the kneading of the product of the second fermentation of the wheat-milk mixture may be too heavy a task for a woman, and a male hired help may be employed for that specific chore. For the stage of shaping into balls and arranging in rows to dry on the reed mats, the women of the family and/or the neighbors join in, and the favor is returned when it is their turn to produce *kishk.*

Lactic acid fermented foods generally require little, if any, heat in their fermentation and can be consumed without cooking. This zero energy demanding technique represents significant energy savings that is important to rural families. KS technology has withstood the test of time probably because it is a low-cost way of preserving and securing food availability during food shortage periods. Furthermore, it contributes to the improvement of the nutritional value and digestibility of the raw materials used.

2.4. Commercialization of the product (market opportunity, domestic and international trade, price structure)

Due to lack of data pertaining to marketing and pricing of KS, it is difficult to estimate the turnover of the national production of *kishk*. KS is very popular locally in Upper Egypt and can be found in village markets and sometimes in urban markets in some of the popular neighborhoods at a price ranging from 5-12 LE/Kg (equivalent to 0.9 to 2.18 USD) which is within the means of the majority of consumers. (Ahmed ZS, Personal communication 2010).

Some data on the consumption/production of *Kishk* have been reported from the following countries (1) Iraq: in the 1960s the estimated annual per caput consumption of *Kishk* in the northern region ranged between 20 and 30 kg (Platt, 1964; Kurmann et al., 1992). (2) Turkey: the *trahana* produced locally is consumed at a level of 8 kg per caput per annum (Platt, 1964). (3) Lebanon: the average yearly production of *kishk* is about 1000 tonnes (FAO, 1990) for a population estimated at 2 974 000 for that year (UN World Population online database).

3. QUALITY CHARACTERISTCS OF KS

3.1. Nutritional quality

The nutritional impact of fermented foods on nutritional disorders can be direct or indirect. Food fermentations that raise the protein content or improve the balance of essential amino acids or their availability can have a direct therapeutic effect. Similarly fermentations that increase the content or availability of vitamins such as thiamine, riboflavin, niacin or folic acid can have direct effects on the health of the consumers of such foods. This is particularly true of people subsisting largely on maize where niacin or nicotinic acid is limited and pellagra is incipient. The same is true for people subsisting principally on polished rice which contains limited amounts of thiamine and beri-beri is incipient (Jelliffe, 1968). Biological enrichment of foods through fermentation can prevent this. Tannin levels may be reduced as a result of lactic acid fermentation, leading to increased absorption of iron, except in some high tannin cereals, where little or no improvement in iron availability has been observed (Nout and Motarjemi, 1997).

Not much detailed information is available on the nutritional quality of KS. However, *kishk* can be generally considered as a balanced food with excellent preservation qualities, richer in B vitamins than either wheat or milk alone, and well adapted to hot climates by its content of lactic acid (Abd-el-Malek and Demerdash, 1993; Mahmoud, 1993; Morcos, 1993). Some modifications, such as the substitution of whole wheat-meal by bulgur in the making of *kishk* have been proposed (Tinay et al. 1979). It has been found that substitution by bulgur enhances the availability of Ca, Fe, Mg and Zn and improves the utilization of wheat nutrients, without undue effects on the acceptability of the final product.

On the whole, KS is a highly nutritious food, having a protein content of about 23.5% (Morcos, 1993). It is of a high digestibility and has a high biological value. *Kishk* has good nutritional and microbiological qualities. Fermenting the milk makes it easier to digest and the high fibre content is in line with current trends for good nutritional practice. The milk-cereal mix in KS provides a source of affordable balanced proteins that are particularly valuable for children. The fermentation process raises the micronutrient density of a final product that is characterized by being low in saturated fats and high in fiber.

3.2. Microbiological quality

There are only four main fermentation processes: alcoholic, lactic acid, acetic acid and alkali fermentation (Soni & Sandhu, 1990). Lactic acid fermentation (e.g. fermented milks and cereals) is mainly carried out by lactic acid bacteria. Lactic acid fermentation contributes towards the safety, nutritional value, shelf life and acceptability of KS.

According to Aguirre and Collins (1993), the term LAB (lactic acid bacteria) is used to describe a broad group of Gram-positive, catalase-negative, non-sporing rods and cocci, usually non-motile that utilize carbohydrates fermentatively and form lactic acid as the major end product. According to the pathways by which hexoses are metabolized, they are divided into two groups: homofermentative and heterofermentative. Homofermentative such as Pediococcus, Streptococcus, Lactococcus and some Lactobacilli produce lactic acid as the major or sole end product of glucose fermentation. Heterofermenters such as Weissella and Leuconostoc and some Lactobacilli produce equimolar amounts of lactate, CO2 and ethanol from glucose (Aguirre & Collins, 1993; Tamime & O’Connor, 1995).

Lactic acid fermentation technology has been found to be a very effective way by which Egyptians for centuries have improved their food raw materials to make them palatable and safe for consumption (Oyewole, 1997). Lactic fermentation improves the nutritional quality of food in the following basic ways:

- by the detoxification of food raw materials to make them safe for consumption;
- by improvements of functional properties; and
- by improving the digestibility and nutritional value of food products.

The microbiology of KS is quite complex and not known. The acidic nature of KS, coupled with low moisture content and the presence of salt and cumin, represent unfavorable conditions for the survival of coliforms and *Staphylococcus aureus.* Atia & Khattab (1985) detected faecal streptococci (possibly, *Enterococcus faecium)* in only one out of eight samples of *kishk* tested (at a level of 3.4 x 16' colony-forming units per gm (CFU g-). These authors attributed the presence of this organism in the *kishk* sample to its high pH (4.70 compared with an average of 4.17 for the other samples), and its low salt content (4.15% compared with 8.9%).

3.3. Physico-chemical and sensory characteristics

Fermentation is carried out to enhance taste, aroma, shelf-life, texture, nutritional value and other favorable properties of foods (Mensah, 1997; Nout & Motarjemi, 1997; Steinkraus, 2002). Some modifications, such as the substitution of whole wheat-meal with bulgur, have been proposed in the formulation of *kishk* (Tinay et al. 1979). From the organoleptic point of view, the whole wheat-meal KS is reported to be granular, more sour, less cohesive, contains more bran particles, and is more yellowish in color than the traditional (Lebanese) bulgur *kishk.* Also, the production cost is lower when whole wheat meal is used in the making of *kishk*.

The sensory properties of Lebanese *kishk* reconstituted with water and served as a hot porridge or gruel have been reported by Muir *et al*. (1995). The Lebanese product made with caprine milk was clearly distinguishable from the rest of the *kishk* samples. Tamime *et al*. (1997) found that the mouth-feel attributes (grainy, sticky and slimy character) of *kishk* were associated with the type of bulgur used (e.g. made from wheat, barley or oats).

The effect of the substitution of whole wheat meal for bulgur in the formulation of Lebanese *kishk* was investigated by Toufeili et al (1999). The soup prepared from both formulae i.e. bulgur and whole meal were comparable to a certain degree. However, whole wheat meal *kishk* was significantly ($p < 0.05$) more yellowish in color, more sour, less gritty, less cohesive and contained more bran particles than the bulgur-based formulation. These findings suggest that substitution of whole wheat meal for bulgur in the formulation of *kishk* enhances the nutritional quality without undue effects on the acceptability of the final cooked *kishk*.

In contrast, except for the pleasant acidic and sour taste of KS, little is known of the sensory quality of the product.

3.4. Product quality perception/requirement by consumers

While fermented foods are themselves generally safe, it should be noted that fermented foods by themselves do not solve problems related to contaminated drinking water, environments that are heavily contaminated with human waste, improper personal hygiene of food handlers, or exposure to flies carrying infectious disease organisms. Also, incomplete fermention of food can be unsafe. However, application of the principles that can guarantee the safety of fermented foods could lead to an improvement in the overall quality and the nutritional value of the final food product.

A valid concern is that of mycotoxins that may be present in the wheat before fermentation. They are produced when the cereal grains are improperly harvested or stored. During soaking and cooking of the raw substrates before fermentation, many potential toxins such as trypsin inhibitor, phytate and hemagglutinin are destroyed. So, on the whole, fermentation can have a detoxification action on the substrates.

Svanberg *et al.* (1992) and Svanberg (1996) reported that lactic acid-fermented gruels inhibited the proliferation of Gram-negative pathogenic bacteria including toxicogenic *Escherichia coli, Campylobacter jejuni, Shigella flexneri* and *Salmonella typhi-murium.* The mean number of diarrhea episodes in pre-school children over a 9 month period was 2.1 per child receiving fermented gruels compared with 3.5 per child receiving non-fermented gruels for the same period.

Minimizing contamination of the raw materials is important for controlling pathogen levels in the final product. Measures should be taken to interrupt the transmission of pathogens to fermented foods at both the household and commercial levels. At the commercial level, improvement of product quality and safety could be achieved by applying Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP) and the Hazard Analysis and Critical Control Point (HACCP) system. Guidelines are needed for applicatuion of the HACCP system in the production of traditional fermented foods such as kishk. However, educating food handlers, particularly housewives and food vendors in the basics of food hygiene is a strategy that can be used for prevention and control of food-borne diseases.

4. CONSUMPTION PATTERNS OF THE KS

4.1. Food forms

KS forms part of the regular food intake of the average individual in the south of Egypt. Egyptians consume KS at all meals under different forms of preparation and it serves as the food of choice for the sick. KS is usually reconstituted with water and is consumed as a hot gruel, often with the incorporation of vegetables, spices, garlic, herbs or dates. It can form the core ingredient in savory and sweet dishes (Morcos et al 1973).

One of the unique features of KS is that it can be eaten at all stage of preparation (Ahmed ZS and Hassan-Wassef H, unpublished data). Diluted *Laban Ze*er is consumed in summer on its own as a refreshing drink. The *hama* (mixture of *Laban Zeer* and parboiled ground wheat) is consumed as a sour paste for breakfast or as a semisolid mash as an accompaniment to vegetables and eggs. The final dried balls/chunks can be eaten as a snack and are a common school snack for Upper Egyptian children. Reconstituted in water, KS serves as the basis for preparation of many savory and sweet dishes. It can be cooked with meat or poultry as a kishk stew. Two KS balls soaked in a glass of water is the first drink on waking up in the morning for many Upper Egyptian women.

For households with limited incomes, a few KS balls thrown in the cooking pot replace meat in the preparation of the daily vegetable stew.

4.2. Period of the day for consumption

Together with bread - KS is a basic component of the dietary system for Upper Egyptians and can be consumed at all meals, morning, mid-day or evening.

5. RESEARCH ACTIVITIES AND NEW ACTIVITIES DEVELOPMENT ON TECHNOLOGY AND PRODUCT

Although all KS consumed in Egypt is homemade and therefore sun-dried, a mathematical model of direct sun and solar drying of laboratory prepared KS was developed by Bahnasawy and Shenana (2004). The model was able to predict the drying temperatures at a wide range of relative humidity values. It has also the capability to predict the rate of moisture loss from the product at wide ranges of RH values, temperatures and air velocities.

A great deal of attention has been paid towards the production of instant or ready to use dehydrated KS and to evaluating the quality of the developed product. The data obtained revealed a good acceptability for the instant products as compared to their parent form. Moreover, the computed protein efficiency ratio (PER) obtained from its amino-acid composition, the FAO/WHO pattern for essential amino-acids, and the in-vitro digestibility were significantly improved.

In order to enhance further the potential improvement in the application of the KS processing technology, there is need for more research, technology transfer with due consideration to the socio-economic implications. Studies are needed to cover areas of concern such as food safety, processing techniques and nutritional value. Specifically, research is needed to challenge the hitherto uninvestigated lactic fermentations, to determine the need for and feasibility of using starter cultures and probiotic microorganisms, and to optimize fermentation conditions for achieving specific health benefits. Traditional lactic fermentation processes in Egypt will be greatly improved with the development and application of quality and safety systems such as

GMP and HACCP. Like all foods, lactic acid fermented foods will need to be made to stand up to the challenges posed by the existing risk of contamination with newly emerging pathogenic bacteria, viruses, and parasites. All these investigations will need to be done to meet the producers' and consumers' specific needs. Transfer of information and technology to household and cottage industry levels calls for participatory pilot projects that are replicable.

From a nutritional point of view, new insights leading to increase in nutrient and energy density and to the removal of phytic acid, offer opportunities for future improvement of nutrient uptake by consumers of KS.

CONCLUSION AND PERSPECTIVES ON RESEARCH AND INNOVATION NEEDS

Traditional KS products have been produced for centuries in Egypt and are very popular and appreciated by millions of Egyptians. It can be concluded that in temperate regions, mixed natural fermentations of cereals with lactic acid bacteria and yeasts (‘‘sourdough fermentations’’) are widely practiced. These fermentations play an important role in providing wholesome food with an attractive flavor and texture.

Based on the available information reviewed here above, a number of conclusions can be drawn. *Firstly*, Provision of technical support that accelerates and guides the evolution of the production process of the home-based the cottage industries can upgrade the quality and increase the market share of traditional products. However, the natural resources, culinary traditions, culture, and current overall level of development in the country should be carefully taken into consideration. In this regard, it is worthwhile to point out that the production of KS is historically considered as an exclusively female occupation. Hence, the organization of *kishk* producing women into co-operatives and associations to manage such technologies may be a means towards:

- The enhancement of the added-value of indigenous foods, and in turn, increasing the income of rural women.;
- Making available to local consumers a variety of indigenous and highly appreciated products at affordable prices. Products that are improved in quality and safety and that keep well.

Secondly, mechanization of some key processing stages is desirable, for example, the manual mixing of the ingredients *(Laben Zeer*, ground wheat, salt, and condiments) in traditional KS making can be replaced by using an appropriate mixing machine. Such a replacement will ensure optimal homogeneity of the different ingredients, and avoid possible contamination of the product that may originate from the KS operatives and/or handlers.

Thirdly, there is scope for improvement of, a) the open air method used for drying to avoid contamination, and b) the packaging of the products after processing. In the traditional methods, the KS is packed (stored) in earthenware jars. In the industrial production of second generation KS derivatives, the packaging and labeling must be done with due care and in compliance to the specific statutory standards. This is important not only for marketing reasons, but also to protect the product from post processing contaminations and/or accelerated deterioration.

Fourthly, from a nutrition point of view, new methods for increasing nutrient and energy density and for removal of phytic acid, offer opportunities for future improvement in nutrient uptake by consumers.

Fifthly, ,The popularity of ready-to-eat food items among both the food processing companies and the consumers offers excellent opportunities for diversification by production and marketing of a variety of intermediate KS products to consumers. One could imagine that fresh or frozen KS sourdough is packed in modified atmosphere packs and used as a thickening ingredient in stews and gravies. Dehydrated sourdough prepared from different cereal mixes and extraction rates can be used in the production of baby foods and for thickening of soups. These could open novel culinary and technological applications, commercially and at home. Innovative research is needed to produce second generation KS products that are adapted to the preferences of the modern consumer and to the demands of modernity. This could lead to commercial exploitation of the advantages of KS such as the affordable price, the relatively high nutritional quality, the low energy input required for its production and the low environmental impact of its production method.

REFERENCES:

Abd-el-Malek, Y., & Demerdash, M. 1993. Egyptian kishk. In K. H. Steinkraus (Ed.), *Handbook of indigenous fermented foods* (pp. 295–299). New York: Marcel Dekker.

Aguirre, M., & Collins, M. D. (1993). Lactic acid bacteria and human clinical infection. *Journal of Applied Bacteriology*, 62, 473–477.

Atia, I. A. & Khattab, A. A. 1985. Microbiological and chemical studies on Kishk. *Alex.Sci. Exch., 6, 63-71*.

Bahnasawy A.H. Shenana M.E. 2004. A mathematical model of direct sun and solar drying of some fermented dairy products (Kishk). *Journal of Food Engineering* 61: 309–319.

Blandino A. Al-Aseeri M.E., Pandiella S.S., Cantero D., Webb C. 2003. Cereal-based fermented foods and beverages. *Food Research International* 36 (2003) 527–543.

Cadena, M. A. & Robinson, R. K. 1979. The acceptability of yoghurt-cereal mixtures to a rural community in Mexico. Ecology Food Nutr***., 8,*** 169-74.

El-Gendy, S. M. 1983. Fermented foods of Egypt and the Middle East. *Journal of Food Protection*, 46, 358-67**.**

El-Gendy, S. M. 1986. Fermented foods of Egypt and the Middle East. In *Indigenous Fermented Food of Non-Western Origin*, ed. C. W. Hesseltine & H. L. Wang. J. Creamer,
Berlin, Germany, pp. 169-92.

El-Gendy, S. M. 1983. Fermented foods of Egypt and the Middle East. *Journal of Food Protection*, 46(4), 358–367.

FAO 1990. The Technology of Traditional Milk Products in Developing Countries.
Animal Production and Health Paper 85, Food and Agriculture Organization of the
United Nations, Rome, Italy, pp. 51, 315.

Hesseltine, C. W. 1979. Some important fermented foods of mid-Asia, the Middle East and Africa. *Journal of the American Oil Chemists's Society* 56, 367-47.

Jandal, J. M. 1989. Kishk as fermented dairy product. *Indian Dairp~un, 41, 479-48* 1.

Jelliffe, D.B. (1968) *Infant Nutrition in the Tropics.* World Health Organization. Geneva. Switzerland.

Kurmann, J. A., Rasic, J. Lj. & Kroger, M. 1992. *Encylopedia of'Fermented/ Fresh Milk*

Products. Van Nostrand Reinhold, New York, pp. 81-287.

Mahmoud, S. A. Z. (1993). Egyptian kishk. In K. H. Steinkraus (Ed.), *Handbook of indigenous fermented foods* (pp. 295–299). New York: Marcel Dekker.

Mensah, P. 1997. Fermentation—the key to food safety assurance in Africa. *Food Control*, 8, 271–278.

Morcos, S. B., Hegazi, S. M. and El-Damhougy, S. T. 1973. Fermented foods in common use in Egypt I. The nutritive value of kishk. *Journal of the Science of Food and Agriculture 24, 1153-l I56.*

Morcos, S. R. (1993). Egyptian kishk. In K. H. Steinkraus (Ed.), *Handbook of indigenous fermented foods* (pp. 295–299). New York: Marcel Dekker.

Muir, D. D., Tamime, A. Y. and Hunter , E. A. 1995. Sensory properties of Kishk: comparison of products containing bovine and caprine milk. *Journal of the Society of Dairy* t*echnology*, 48, 123-127.

Nout, M. J. R., & Motarjemi, Y. (1997). Assessment of fermentation as a household technology for improving food safety: a joint FAO/WHO workshop. Food Control, 8, 221–226.

Olusola B. Oyewole, BA. 1997. Lactic fermented foods in Africa and their benefits. *Food Control*, 8, No. 5/6: 289-297.

Platt. B. S. 1964. Biological ennoblement: Improvement of the nutritive value of food and dietary regimens of biological agencies. *Food Technolology*, 18**,** 622-70.

Soni, S. K., & Sandhu, D. K. (1990). Indian fermented foods: microbiological and biochemical aspects. *Indian Journal of Microbiology*, 30, 135–157.

Steinkraus. K. H. ed. *1983. Handbook of' Indigenous Fermented Foods.* Marcel Dekker Inc., New York, USA, pp. 244-99.

Steinkraus, K. H. 2002. Fermentations in world food processing. *Comprehensive Reviews in Food Science and Food Safety*, 1, 23–30.

Svanberg, U., Sjogren, E., Lorri, W., Svennerholm, A.-M. and Kaijser, B. 1992. Inhibited growth of common enteropathogenic bacteria in lactic-fermented cereal gruels. *World J. of Micro and Biotech. 8*, *60* I-606

Tamime , A. Y. and O'Connor, T. P. 1995. Kishk: A dried fermented milk/cereal mixture. *International Dairy Journal*, 5, 109-128.

Svanberg, U. 1996. Lactic acid fermented foods for feeding infants. In *Handbook of Indigenous Fermented Foods.* ed. K.H. Steinkraus, pp. 310-321. Marcel Dekker, New York.

Tamime A.Y. , D. D. Muir, D.D. Barclay M.N.I ,Khaskheli M. McNulty, D.1997. Laboratory-made Kishk from wheat, oat and barley: 2. Compositional quality and sensory properties. *Food Research International*, Vol. 30, No. 5, pp. 319-326.

Tinay, A. H. E., Addel Gadir, A. M., & Hidai, M. E. 1979. Sorghum fermented kisra bread. I. Nutritive value of kisra. *Journal of the Science of Food and Agriculture*, 30, 859–863.

Toufeili,I. , Melki C., Shadarevian S. Robinsonb R.K. 1999. Some nutritional and sensory properties of bulgur and whole wheat meal kishk (a fermented milk-wheat mixture). *Food Quality and Preference* 10 9-15.

Van Veen, A. G. & Steinkrdus, K. H. 1970. Nutritive value and wholesomeness of fermented foods. *J. Agric. Food Chem., 18,—576-8.*

Wang, H. L. & Hesseltine, C. W. 1981. Use of microbial cultures: Legume and cereal products. *J. Food Technol., 36, 79-83.*

Youssef M. M. 1990. Instantization and evaluation of some traditional Egyptian foods. Food chemistry, 38(4): 247-254.

Literature review and Background information of *Lanhouin*

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:

Anihouvi, V., Kindossi, J. and Hounhouigan, J.

Faculty of Agronomic Sciences, University of Abomey-Calavi (Benin)

Edited by: Annali Jacobs

December 2010

Table of contents

Abstract

Lanhouin, a traditionally processed fermented fish, is widely used as a food condiment in urban and rural areas in Southern Benin and in the neighbouring countries of Togo and Ghana. Lanhouin is processed by spontaneous fermentation and its production is largely artisanal. Two variations of the traditional processing method are practiced, both apparently producing the same final product. Salt is used as the main additive and its ratio varies from one processing site to another and from one processor to another. Since in the traditional processing method of lanhouin, the fish must be in partially deteriorated form, chemical and microbiological changes are expected. Work carried out on lanhouin samples purchased from processors and retailers showed that the histamine contents in most of the samples (75%) exceeded the recommended level of 20 $mg.100g^{-1}$; the microbial loads in the same samples were high as well. In this respect, the processing of fresh fish into lanhouin was investigated with the objective to identify the micro-flora responsible for the fermentation and the biochemical changes, brought about in the product. A number of problems associated with the traditional processing were also identified. These include lack of proper hygienic practices during processing, rudimentary packaging, contamination of product, the re-use of salt for subsequent fermentation, insect infestation and poor quality of the end product. Lanhouin is also susceptible to larvae infestation, mould growth and bacterial spoilage during storage. From the fermentation study, it appears that the microbial population of lanhouin consists largely of a variety of halophilic Gram-positive bacteria types and, to a lesser extent, Gram-negative bacteria. This review is intended to provide comprehensive knowledge on the processing of fresh fish into lanhouin, which will facilitate the development of the traditional operations to a level where it can be integrated into the formal sector of the food industry in Benin.

Introduction (definition of product, origin and cultural background)

Lanhouin, a typical Beninese fermented fish, is widely used for its flavour and taste enhancing properties in the West African countries of Benin, Togo, Ghana and Senegal. *Lanhouin*, a a Ghanaian fermented fish like-product called momone is processed by spontaneous and largely uncontrolled fermentation (Nerquaye-Tetteh et al., 1978; Yankah, 1988; Essuman, 1992; Abbey et al., 1994; Anihouvi et al., 2005). Similarly to other African countries, artisanal fish processing remains the predominant and most important method of fish preservation in Benin. The principal methods are smoking, sun-drying, salting, frying and fermentation. These processes may either be used alone or combined in order to achieve the desired product. For instance, salting and sun-drying are often combined with fermentation to get a well-preserved product. The choice of a particular processing method is greatly influenced by the geographical location of the area, socio-economic factors and the food habits of the local people. Traditionally, many commodities (maize, sorghum, millet and fish) are processed in Benin by the cottage industries into fermented foods, which constitute the most important part of the staple foods, beverage, weaning foods and condiments consumed in the country (Hounhouigan, 1994; Anihouvi et al., 2005; Azokpota et al., 2006; Vieira-Dalodé et al., 2007). Salted, fermented and sun dried fish is generally known as “fermented fish” (Beddows, 1985). Fermented fish is any fishery product, which has undergone degradative changes through microbiological and enzymatic activities either in the presence or absence of salt (FAO, 1993**).** In Benin, the fermented fish is called lanhouin, a Mina word which literally means smelling fish (Anihouvi et al., 2005). The name lanhouin refers to a group of popular fermented fish products common to West Africa countries (Essuman, 1992). Some of the major fermented fish produced in West Africa are: momone, koobi and kako in Ghana, lanhouin in Benin and Togo, and adjuevan in Ivory-Cost (Nerquaye-Tettteh et al., 1978; Yankah, 1988; Essuman, 1992; Anihouvi et al., 2005).

In contrast to Southeast Asian region where fish fermentation normally lasts for several months (three to nine months) and the fish flesh may liquefy or turn into a paste, in Benin salting and drying of fish for preservation is accompanied by fermentation as well, but the period is short (few days) and the product is not transformed into a paste or sauce (Huss & Valdimarson, 1990; Essuman, 1992; Anihouvi et al., 2005). Lanhouin can be described as highly salted and semi-dried fishery product which had developed a strong odour. Areas of production of *lanhouin* are mainly the coastal landing centres (Atlantic and Mono Districts) of the country; in those areas the production of lanhouin is the main economic activity of the women of the two ethnics groups called *Xla* and *Mina* (Anihouvi et al., 2005).

1. Traditional processing of lanhouin

The production of lanhouin is an artisanal activity. Lanhouin is processed by spontaneous and largely uncontrolled fermentation. This fermentation usually involves the use of mixed cultures in solid substrate. Solid substrate fermentation refers to any fermentation that occurs on a solid or semi-solid substrate (Aidoo et al., 1982). Koobi, momone and lanhouin are listed as some indigenous Ghanaian and Beninese fermented fish products, which are produced by solid-substrate fermentation (Essuman, 1992; Abbey et al., 1994; Kingley-Ekow, 1999; Anihouvi et al., 2005). The advantages of solid substrate fermentation include superior productivity, simpler techniques, reduced energy requirements and low waste water output (Aidoo et al., 1982).

Various processing methods in fish fermentation are used in different localities and the particular method used depends largely on availability of salt and the food habits of the local people (Beddows, 1985; Olympia, 1992; Essuman, 1992; Gram & Huss, 2000). Three main techniques have clearly emerged as methods commonly practised in many African countries: these techniques are: i) Fermentation with salting and drying, ii) Fermentation and drying without salting and iii) Fermentation with salting without drying (Essuman, 1992). For the three processing methods, the end product retains its original form**.** Lanhouin belong to the category of fermented fish obtained by the combination of salting, fermentation and drying.

Most of traditional lanhouin processing plants are rural and informal and the fermentation processes are handed down from generation to generation. The processing sites are mostly located close to the beach; processing activities are carried out late in the evening or early in the morning to avoid high temperature during the first stage of processing and to prevent contact of fish with flies. Activities are carried out mostly by illiterate women as the major operators (Anihouvi et al., 2005). The methods of processing were developed in homes and improvements were based on the observations of practitioners. There is little interest in knowing the role of micro-organisms and the chemical changes that occur in the product. What is recognized are changes in texture, colour, odour and taste. Two variations were noted in the procedures employed for the processing of fresh fish into lanhouin, but both apparently lead to the same end product (Fig.1) (Anihouvi et al., 2005).

1.1. Raw materials and additives used and their handling

The main raw materials used for lanhouin processing include fresh fish which had not been subjected to any cooling preservation or salt treatment.

Fish

Different types of fish can be used for lanhouin processing, but those mentioned by the processors are listed in table 1. However, the majority (97%) of processors interviewed claimed that they mainly use cassava fish/cassava croaker (*Pseudotolithus* sp.) followed by lesser African threadfin (*Galeoides decadactylus*) (91% of processors) and king fish/spanish markerel (*Scomberomorus tritor*) (77% of processors) (Anihouvi et al., 2005). Cassava croaker and spanish markerel are mainly used for the processing of momone, in Benin as well as in Ghana (Abbey et al, 1994). According to the processors, types of fish not cited in table 1 are not recommended for lanhouin processing because lanhouin from those species often cause itch when they are used to season non-cooked tomato sauce named “monyo” (Anihouvi et al., 2005). Species of concern include for example tuna (*Sarda sarda*), sardine (*Sardinella maderensis*) and aloes (*Hisha africana*).

Various authors have reported that fresh fish is not well handled and stored in developing countries (Watanabe, 1982; FAO, 1989; Gram & Dalgaard, 2002). The current methods of fish handling and processing are generally inadequate. Onshore fish handling in the artisanal sector is often poor; fish are usually scooped out of the boats with all sorts of containers. This method of unloading the catch by hand takes considerable time during which the temperature of the fish also increases considerably. For those reasons, spoilage rates are extremely high compared to those in temperate climates and according to observations some species can become completely spoilt 10 to 12 hours after catching and sometimes after 5 to 7 hours (Huss, 1988). In addition, the environment in which fishes are processed is generally unhygienic, paving the way for microbial contamination and production of food toxicants such as histamine (Anihouvi et al., 2006). This shows that there are basic educational problems, such as lack of awareness of the importance of hygiene.

Table 1: Types of fish used for lanhouin processing in Benin

Local names	**Common names**	**Scientific names**
Agbanmandou/Zadou	**Kingfish/spanish mackerel**	***Scomberomorus tritor***
Ekan/djoke	**Cassava croaker**	***Pseudotholithus sp.***
Figni	Senegal jack	*Caranx senegalensis*
Gbohloué	Milk shark	*Rhizoprionodon acutus*
Glanmatan/kobi	Longfin pompano	*Trachinotus goreensis*
Guinfio/guinlénou	Royal treadfin	*Pentanemus*
Hawui	Bigeye grunt	*Brachydenteus auritus*
Kokoui	Bastard grunt	*Pomadasys sp.*
Kpankpan	Crevalle jack	*Caranx sp.*
Lizi	Guachanche barracuda	*Sphyraena guachancho*
Signivi	Atlantic horse mackerel	*Trachurus trachurus*
Sika-sika	Congo dentex	*Dentex sp.*
Tchikoué	Lesser African threadfin	*Galeoides decadactylus*
Zozrovi	Atlantic bumper	*Chloroscombrus chrysurus*

Source: Anihouvi et al., 2005

Salt

Imported salt and sun-dried sea salt are the two types of salt used in Benin for fish curing prior to fermentation. The correct use of salt during the artisanal production of fermented fish is known to delay the onset of bacterial spoilage and reduce the susceptibility of the product to insect infestation (Sefa-Dedeh, 1995; Horner, 1997). Salt also imparts a flavour to the product. In Benin, where solar salt is available and inexpensive, fermented fish is heavily salted. Sun-dried sea salt, however, is noted for its poor microbiological quality (Sefa-Dedeh &Youngs, 1976; Essuman, 1992). Certain types of bacteria, which can live in strong brine or in solid salt, have been found practically in every case where salt obtained from seawater was used. These halophilic bacteria, which can grow at salt concentrations of 13 % and above, confer a reddish colour on salted and fermented fish (Beddows, 1985; Essuman, 1992; Sefa-Dedeh, 1995; Anihouvi et al., 2005).

Very pure sodium chloride would be the most desirable for curing purposes. However, the end product of fish salted with the pure sodium chloride is not desirable as compared to fish salted with salt containing small amounts of calcium and magnesium (Beddows, 1985; Horner, 1997). The salt to be used for fish curing should have approximately 0.50 % calcium and magnesium impurities, although in the case of greater levels of such impurities in the salt, Ca^{2+} and Mg^{2+} ions bind with protein and form a barrier to the passage of Na^{+} ions through the thicker part of the fish flesh (Horner, 1997). Traditional methods of fish curing in Benin involve rubbing dry salt into the belly cavity, the gills and on the surface of the fish or making alternate layers of salt and fish. There are often problems with these methods because the concentration of salt in the flesh is not sufficient to preserve the fish, as it has not been uniformly applied (Beddows, 1985; Anihouvi et al., 2005). A better technique is brining which involves immersing the fish into a pre-prepared solution of salt. The advantage is that the salt concentration can be controlled easily and salt penetration is more uniform.

1.2. Description and variability/similarity of processing methods (with flow diagrams, equipment and promising technology)

The fermentation period varies from three (3) to eight (8) days and depends on the species of fish and marketing conditions. At the end of fermentation, the fish is sun-dried for 2 to 4 days. For processing of lanhouin, fresh fish is scaled, gutted and sometimes cut into pieces and then left overnight at ambient temperature for ripening. The next day, the seemingly spoiled fish is washed. Dry salt is rubbed into the gills, the belly cavity and on the surface. After this first salting, the fish is arranged in a basket, a can or a hole, covered with old cement paper bag and old clothes and allowed to ferment for three (3) days at room temperature before being removed, washed lightly and sun dried. Sometimes on the third day after the fish has been removed and washed lightly, a second salting may be done and fermentation allowed to progress until the 8^{th} day before sun drying. Two variations were noted in the traditional processing method. For the first variant the fresh fish is gutted before being ripened (left overnight) without water while for the second one the fresh fish is ripened in sea water before gutting (Fig.1). According to the processors, this first step, which involves leaving the fish overnight, is very important for the production of good, soft textured and well flavoured lanhouin. Salt ratio used during the processing range between 20 and 35% by weight of fresh fish for the first salting while for the second salting, the quantity of salt accounts for approximately 15-25 %. The processing activities are carried out late in the evening or early in the morning to avoid high temperature during the first stage of processing and to prevent contact of fish with flies.

.

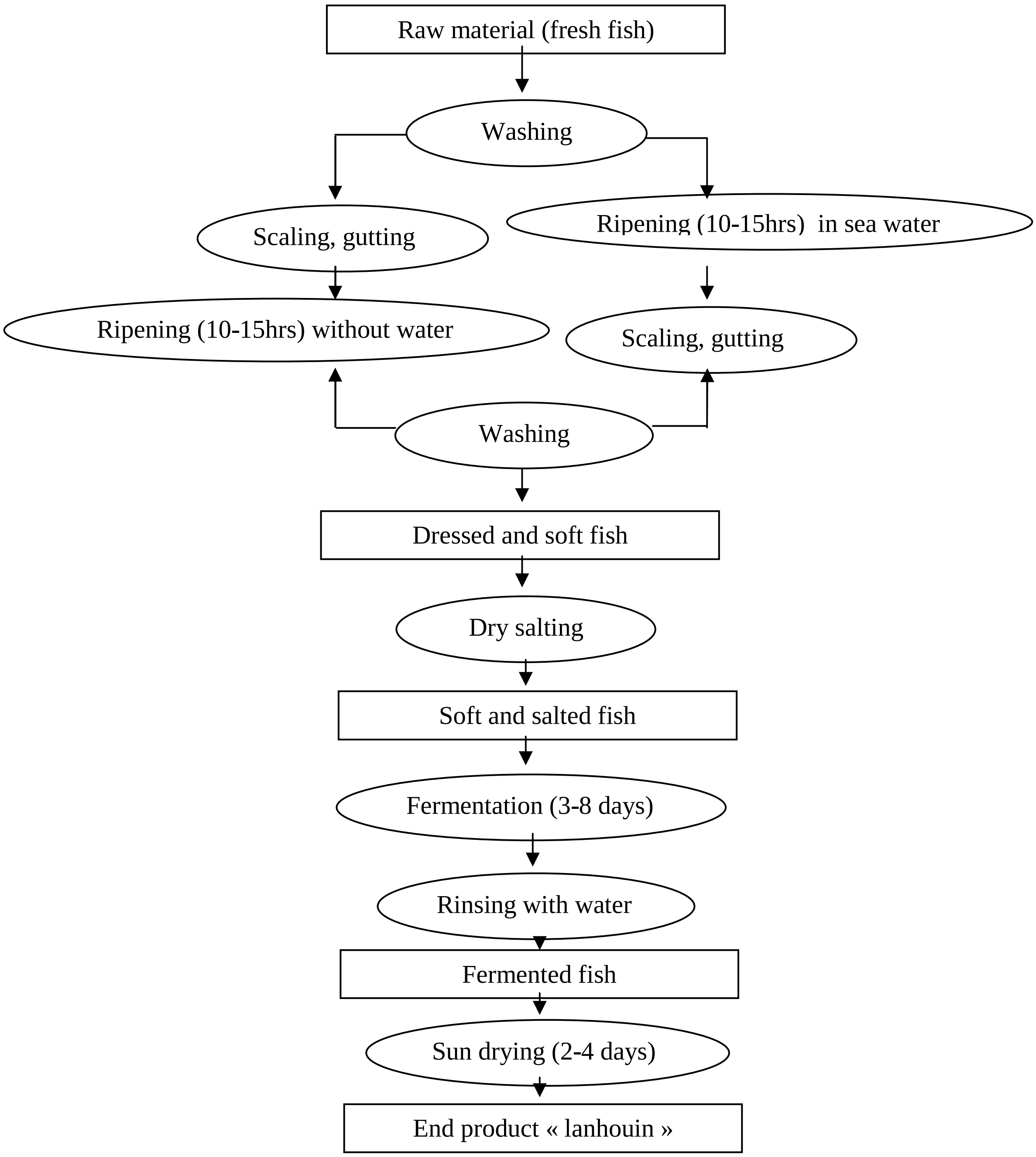


Fig.1: Flow diagram of the traditional processing of lanhouin in Benin from Source: Anihouvi (2006)

Utensils and other simple pieces of equipment such as knives used by lanhouin processors are shown in Table 2.

Table 2: Equipment used for lanhouin processing

Processing steps	Utensils, etc
Washing	Bowl
Gutting	Knife
Salting	Bowl
Fermentation	Basket, can, hole, claypot, concrete vats
Washing off salt	Bowl
Storage and packaging for sale	Basket, cement paper bag

Source: Anihouvi (2006)

1.3. Major problems associated with processing methods

The major problems observed with the lanhouin processors are the general unhygienic conditions of the processing environment as well as the equipment used for processing. Other improper handling practices noticed include the use of dirty water for washing the fish and improper packaging of the product. Washing the fish with dirty water can cause contamination of the fish. Dirty water contaminated with faecal matter could harbour coliforms such *Esherichia coli*, which is a prolific histamine producer. The ratio of salt used varies from one production site to another and from one processor to another, and is not usually quantified. As salt is the only preservative agent used, low salt fermentation could possibly permit the growth of some pathogenic organisms in the product. In addition the salt is not stored under good conditions and most of the time the salt is reused in subsequent fermentations. This practice could be a potential source of contamination by halophilic bacteria. Flies also are a big problem to the processors leading to the illegal use of household insecticides to prevent flies setting on the product. The use of insecticides for this purpose poses a health hazard to the consumers. Processors usually package the lanhouin in baskets covered with old sacks, old clothes or cement paper bags during fermentation, storage and when transporting the product to the market. The unhygienic nature of these materials could be potential sources of microbial or other types of contamination.

1.4. Storage methods, maximum duration and problems associated with storage

On the mode of storage, after processing lanhouin is arranged in a basket, a can or hole and wrapped with old jute sacks, paper cement bags and clothes. Very dried fermented fish can be stored for nearly six months but lanhouin, which is a semi-dried product, has a shelf life of up to three months according to processors (Anihouvi et al., 2005). Baskets do not offer any barrier to insect infestation. During storage lanhouin is also susceptible to larvae infestation, mould growth and bacterial spoilage. Another storage problem is the continuous bacterial and enzymatic activity within lanhouin. In a recent study on storage trials with lanhouin it was observed that stored lanhouin continued to undergo further fermentation resulting in instable finished product (Agossou Yao, 2009). The same study revealed that garlic extract or vinegar can be used alone or in combination to improve the shelf life of the product during storage.

2. Socio-economic importance

2.1. Production, processing, handling and storage zones identified in the country

The production zones of lanhouin in Benin are located in the southwestern districts such as Mono/Couffo and Atlantic/Littoral (Fig.2). In these areas lanhouin is a specific product for the ethnic groups called *Xla* and *Mina* (Ewe in Ghana) known as the main processors of lanhouin in the country**.** Nowadays with the migration of these populations towards the urban centres, the consumption of lanhouin is gradually adopted by other ethnic groups living especially in the south of Benin (Anihouvi et al., 2005).

2.2 Socio-economic profile of the actors (processors and retailers)

In Benin, the production and the commercialization of lanhouin are only performed by women. These women mostly have a familial relationship with the fishermen. In general most of them have no formal education. The know-how for production of lanhouin is handed down from mother to daughter across generations. Three main actors were identified in the lanhouin processing sector: the processors, the collectors and the retailers (Anihouvi et al., 2005).

Processors

Three categories of processors were identified: the large scale, the medium scale and the small scale processors (Table 2). The large scale processors produce approximately 200 kg of lanhouin per month while the medium scale processors have a monthly production of 25 - 50 kg. The last category produces less than 25 kg of lanhouin per month; this activity is auxiliary for them. According to the survey of 2001, the production and commercialization of lanhouin constitute the main activity and the main source of income for 75 % of processors interviewed. Ninety five percent (95%) of them work individually but 5 % evolve in group. Thirty five percent (35 %) of large scale processors take part in transborder trade of lanhouin as the collectors.

Collectors

Collectors are mainly West African traders. Approximately 65 % of them come from Togo and Ghana. They collect lanhouin in the markets or in the processing sites. They distribute the collected lanhouin in the Togo and Ghana markets (Fig.2).

Retailers

Contrary to collectors, retailers distribute the product throughout the different markets of the country as found through the survey of 2001. They are supplied from large scale and medium scale processors and sell approximately 15–20 kg of lanhouin per month. In addition to lanhouin some of them sell all kinds of ingredients such as vegetables, tomatoes, salt, etc, needed for the preparation of sauce.

2.3 Socio-economic importance of the product (volume, employment generation, income, food security)

The economic access to the production of lanhouin is related to the type of production practiced (Table 2). The minimum starting capital is approximately 100 000[1] F CFA for medium scale processors and 300 000 F CFA for processors who want to invest in hinterland trade. The turnover of this last category of processor is approximately 2 400 000 F CFA per year with about 500 000 F CFA of net profit. The income from this activity varies according to production importance, the existence of fixed customers and the age of the processor.

Usually, the processors of lanhouin do not have access to an institutional credit, which constitutes an obstacle for expansion of their activity. However, they receive some short term credit from their family or from actors in the supply chain with whom they have built a relation of trust. This credit is used to buy raw materials (fish and salt) and equipment. As it was observed, the production of lanhouin is an activity which is transferred from generation to generation. Thus, a mother, an aunt or a cousin processor whose age is advanced can give her equipment to a younger member to perpetuate this activity in her family.

Table 2: Economical data on the production of lanhouin in Benin

Types of processors	Small scale processors (< 25 kg/month)	Medium scale processors (50 kg / month)	Large scale processors (> 200 kg/month)
Starting capital (fcfa)	25 000	100 000	300 000
Turnover (fcfa)/ year	200 000	800 000	2 400 000

Source: Anihouvi et al. (2005)

[1] 655.96 F CFA = 1 euro

2.4 Commercialisation of the product (market opportunity, domestic and international trade, price structure)

The commercialization of lanhouin follows local, regional and international flows through domestic and external market (Fig.2). International flows are animated by the collectors and some large scale processors whereas local and regional flows are animated by medium scale and small scale processors and retailers. About 3 000 tons of lanhouin are produced per year in Benin, which correspond to an annual turnover of approximately 3 billion F CFA. There are no statistical data on exports, but according to large scale processors, more than 50 % of the production of lanhouin is exported towards Togo and Ghana.

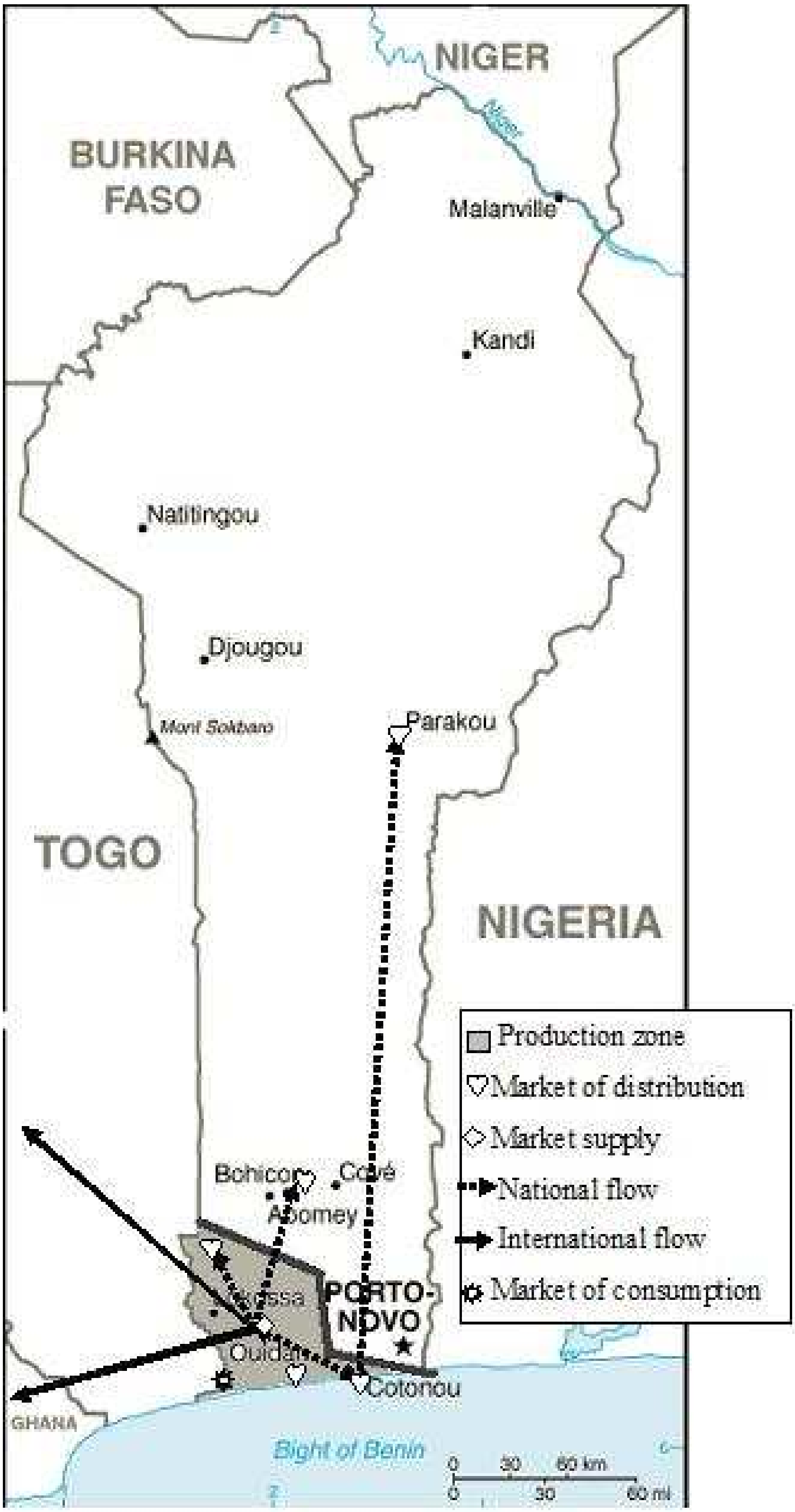


Fig.2: Map of the production zone and the commercialization of local and international axes of lanhouin in Benin. Source: Anihouvi et al. (2005)

3. Quality characteristics of the product

3.1 Nutritional quality

Fermented fish products are added to a variety of diets and contribute greatly to the general nutrition of large populations, particularly in Africa. Fermentation known to improve the balance of essential amino acids or their availability can have a direct therapeutic effect. Indeed fermentation can increase the content or availability of some vitamins in fish. For mineral elements, fish flesh is regarded as a valuable source of calcium, phosphorus and magnesium in particular, but also of iron, copper and selenium. However, processing sometimes tends to affect the nutritional value of fish. The presence of histamine, one of biogenic amines known as food toxicant, is due to the decarboxylation of histidine by microbial activity (Shalaby, 1996). Little information is available on the nutritional quality of lanhouin, however this product can be considered as a highly nutritious, with a protein content of about 25% on a wet weight basis.

3.2 Microbiological quality

Microbiological investigation carried out by Anihouvi et al. (2006 and 2007) on lanhouin on sale and during the fermentation study showed that the predominant microorganisms were largely halophilic types such as *Bacillus* species, coagulase negative *Staphylococcus* and *Micrococcus*. Various authors have reported similar microflora in *momone* (Nerquaye-Tetteh et al., 1978; Yankah. 1988; Abbey et al., 1994) and other fermented fish products (Essuman 1992). *Bacillus* species and coagulase negative staphylococci are known to be involved in various vegetable (Steinkraus, 1991; Dakwa et al., 2005; Parkouda et al., 2009) and meat product (Metz, 1993) fermentation processes. The low counts of coliforms and faecal coli in most of the lanhouin samples purchased from market and processing sites (Table 3) mean that the product is subjected to faecal contamination. The presence of low numbers of *Staphylococcus aureus* and *Clostridium* spp. in some samples of lanhouin is still significant and prove that there is a need for improved handling and processing procedures of lanhouin. The absence of the pathogenic bacteria such as *Salmonella* in salted fermented fish sample is the result of the high salt concentration in the product. It is expected that controlled material handling and fermentation will lead to better microbial status of lanhouin.

3.3 Physico-chemical and sensory characteristics

The physico-chemical composition of lanhouin samples obtained from two types of fish is summarised in Table 3. In general, the moisture contents of samples varied between 45.2 and 55 % for cassava fish lanhouin, and ranged between 51.6% and 61.6% for king fish lanhouin (Anihouvi et al., 2006). This difference in moisture level between the two types of lanhouin is probably due to the high fat content of king fish which limits the removal of water from the fish tissue to the outside during processing. Based on these levels of moisture content lanhouin could be considered as intermediate moisture content product. The pH values of lanhouin samples varied between 6.7 and 7.9. These values of pH are similar to those reported on momone, a lanhouin-like product (Sanni et al., 2002). The averages of free fatty acid (FFA) contents were 12.5 % oleic acid for lanhouin samples obtained from cassava fish and 31.9% for the second group of samples. High level of FFA is an indication of microbial spoilage activity (Pearson, 1976; Huss, 1988; Horner, 1997). Protein contents ranging between 23.4-29.6 %, 20.9-28.3% were found in samples of lanhouin from cassava fish and king fish respectively, and these values did not differ significantly. These values of protein contents are close to those reported in momone and other fish products obtained by solid substrate fermentation (Nerquaye-Tetteh et al., 1978; Abbey et al., 1994; Sanni et al., 2002; Anihouvi et al., 2006). However higher protein content of 57 % was also obtained mainly on fish fermented for two days (Yankah, 1988). These variations in protein levels depend on the intensity of enzymatic and microbial activities and the duration of the fermentation. The reduction of protein content during the fermentation was explained by proteolysis effect leading to the break down of proteins into peptides and amino acids, which could be lost in the exudates (extracted water) from the fish. Abbey et al. (1994) reported protein content of 12 % in the exudates collected during the fermentation of momone.

Chemical compounds such as total volatile nitrogen (TVN) and biogenic amines (e.g. histamine) which do not occur normally in fish muscle are formed by autolysis and microbial action (Table 3). The histamine contents found in lanhouin samples prepared with cassava fish and king fish ranged between 17.4- 25.4 $mg.100g^{-1}$ and 26.5-39.7 $mg.100\ g^{-1}$ respectively (Anihouvi et al., 2006). These levels of histamine exceeded the recommended level of 20 $mg.100g^{-1}$ stipulated by the Australian Food Standards Code, the Food and Drug Administration (USA) and the European Economic Community (EEC) (FDA, 1982; CEE, 1990; AFSC, 2001). However, lanhouin samples obtained from king fish had the highest histamine content; this is expected since king fish belong to scombroid species which are mostly implicated in histamine poisoning (Ahmed, 1991; Kerr et al., 2002). The high level of histamine in the samples is an indication of mishandling during processing and storage; this could also be seen as a result of the low salt concentration of samples, leading to a high activity of histamine producing bacteria. Salt content at least 12% is necessary to avoid histidine decarboxylation activity by biogenic amines producing bacteria (Ahmed, 1991; Deng et al., 1995).

Table 3: Physico-chemical characteristic of lanhouin in Benin (Anihouvi et al., 2006)

Parameters	Means ± Standard Deviations	
	Cassava fish (lean) n = 25	King fish (fatty) n = 25
Moisture (%)	50.1 ± 4.9a	56.6 ± 5.0b
Water activity	0.71 ± 0.06a	0.77 ± 0.1b
pH	7.3 ± 0.6a	7.6 ± 0.3b
Free fatty acids (% oleic acid)[1]	12.5 ± 1.5a	31.9 ± 4.7b
Salt (%)[1]	7.3 ± 1.6a	5.2 ± 1.0b
Total volatile nitrogen (mg N/100 g)[1]	294.5 ± 29.8a	374.5 ± 15.3b
Crude protein (% nitrogen × 6.25)- (g/100 g)[1]	26.5 ± 3.1a	24.6 ± 3.7a
Histamine (mg/100g)[1]	21.4 ± 4.0a	33.1 ± 6.6b

n = number of samples analysed, each sample in duplicate; [1]Wet weight basis
a, b: Means with different letters in a row are significantly different ($p < 0.05$)

3.4 Product quality perception/requirement by consumers

According to consumers the quality standard of good lanhouin is based on its texture, its flavour and its colour (Anihouvi et al. (2005). Thus, consumers qualify a good lanhouin by its wet aspect, its soft texture and its marked flavour. On the sanitary aspect lanhouin does not always have a good image amongst urban consumers. For this category of consumer, the actual processing technique characterized by the total lack of hygiene as well as the conditions under which the fish is processed, do not instil sufficient confidence to eat this product. It is expected that the upgrading of the processing technique and the packaging of lanhouin will contribute to the promotion of lanhouin processing sector.

4. Consumption forms of the product

4.1 Food forms

Lanhouin is mainly used as a food condiment. It is mostly added in small amounts to different types of dishes (fried rice, vegetable sauces, tomato sauces, stew and uncooked tomato sauce called "monyo") (Anihouvi et al., 2005). However in some countries such as Ghana, momone, a lanhouin-like product is consumed as main source of protein when it is grilled and consumed with kenkey, a popular traditional fermented food made from maize (Essuman, 1992)

4.2 Period of the day for consumption (breakfast, lunch, dinner)

In Benin, lanhouin is only used as condiment; it could be consumed at any time of the day. In fact all different types of dishes cited in section 4.1 can be consumed in the morning as breakfast, at the middle day as lunch and in the evening as dinner.

5. Research activities and new development on technology and product

Although all lanhouin consumed in Benin is traditionally made by illiterate processors, a number of studies were carried out on this product. These works are related to the study of the socio-economic importance of the lanhouin sector, the characterization of traditional lanhouin, the study of the fermentation and the development of aroma compounds during the fermentation. The predominant micro-organisms were identified and characterized, and their ability to ferment sterile flesh fish for the production of good sanitary and organoleptically acceptable modern lanhouin was tested. Indeed, to reduce the ripening and fermentation time, an adapted ferment which could be used as starter culture for the traditional lanhouin processing was produced and tested. According to the results, the use of ferment as starter culture for the production of traditional lanhouin led to a reduction in the fermentation time, an improvement in the sensory characteristics of the product and enhanced inhibition or elimination of food-borne pathogens. The optimization of fermentation conditions using response surface methodology was also investigated and a model was developed. The model was able to predict the duration of the ripening and fermentation steps, and the salt ratio that yield a low level of histamine in the end product.

.

However, further studies need to be performed for a better understanding of the traditional fermentation. The role of different predominant micro-organisms in the development of the taste and aroma of lanhouin needs to be investigated. Parameters (temperature, salt ratio, type of salt, ripening procedures, Aw, fermentation material) influencing the fermentation, and their impact on product characteristics need to be established. Two variations were identified in the traditional processing of lanhouin. These are related to the ripening procedure (ripening without water and ripening in sea water). The investigations carried out until now are only related to the first ripening procedure (without water); it would therefore be interesting to investigate the second procedure by using the DII technique and monitor the impact on the quality characteristics of the product on both microbiological and chemical aspects. These studies will provide new knowledge for the re-engineering of the traditional process. The improvement of lanhouin quality and safety also involves the implementation of Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP) and the Hazard Analysis and Critical Control Point (HACCP) system, in order to provide HACCP guidelines for traditional lanhouin processing. It is expected that the new work carried out in this project will offer a modern lanhouin with characteristics adapted to the acceptance of African and European consumers.

Conclusion (Perspectives on research and innovation needs)

Through this review it appears that the use of fermentation as a low-cost method of fish preservation is commonly practised in tropical regions and remote areas where access to sophisticated equipment is limited. Indeed, this review provides comprehensive knowledge which will facilitate the improvement of the traditional operations to a level where it can be integrated into the formal sector of the food industry. The development of local food industries is one of the appropriate solutions to enhance value-added products and the market share of traditional products. In this regard, the culture and the culinary traditions as well as the current level of development of the processing methods in Benin should be taken into account. This is necessary for the success of any action that will be undertaken for the improvement of traditional technology.

Basket-weave is mostly used as fermentation material. However, this material can not assure good control of temperature during the fermentation step. There is a need to find an adequate material for this step of processing. Such replacement of material will ensure optimal fermentation conditions and avoid possible contamination of the product that may originate from the environment of processing. Another point that needs to be raised is related to the packaging of lanhouin. Appropriate packaging of the product after processing requires improvements. In the traditional methods, the lanhouin is usually packed in baskets for storage and transportation to the market. For the new lanhouin processed according to the re-engineered processing method, the packaging must be done according to national or specific standards, not only for marketing purposes, but to protect the product from contamination after processing and to reduce the rate of deterioration during storage.

According to the survey of 2001, women are the main actors in the lanhouin sector since the artisanal production of this product is an exclusively female activity. It is expected that the improvement of processing techniques and the quality of the product will be followed by the enhanced production of value-added of indigenous lanhouin, and consequently will provide better income for women.

References

Abbey, L.D., Hodari-Okae, M., & Osei-Yaw, A. 1994. Studies on traditional processing and quality of fermented fish momone. Artisanal Fish processing and Applied Research Report, Food Research Institute, Accra-Ghana, p48.

Agossou Yao, D.A.R. 2008. Evaluation de l'influence de quelques techniques de conservation sur la qualité microbiologique, physico-chimique et organoleptique du lanhouin, un condiment à base de poisson fermenté. Mémoire d'ingénieur agronome, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, p67.

Ahmed F. 1991. Scombroid (histamine) fish poisoning. Committee on evaluation of the safety of fishery products. National Academic Press, Washington, DC. pp 93-96.

Aidoo, K.E., Henry, R. & Wood, B.J. 1982. Solid substrate fermentations. *Advance Applied Microbiology* 28, 201-237.

Anihouvi V.B, Ayernor S.G., Hounhouigan J.D. & Sakyi-Dawson E. 2006. Quality characteristics of *lanhouin*, a traditionally processed fermented fish in the republic of Benin. *African Journal of Food, Agriculture, Nutrition and Development* 10, 1-15.

Anihouvi V.B, Hounhouigan J.D. & Ayernor S.G. 2005. Production and commercialization of lanhouin, a fermented fish-based condiment from the Gulf of Benin. *Cahiers Agricultures* 14, 323-330.

Anihouvi V.B.2006. Microbiology, chemistry and quality of fermented fish (*Pseidotolithu*s sp.) lanhouin, and its improvement as a food condiment. PhD thesis, University of Ghana, Legon, Accra, Ghana, 224p.

Australian Food Standards Code. 2001. Fish and Fish products. Standards D1 and D2, version 18, National Food Authority.

Azokpota, P., Hounhouigan, D.J. & Nago, M.C. 2006. Microbiological and chemical changes during the fermentation of African locust bean (*Parkia biglobosa*) to produce affitin, iru and sonru, three traditional condiments produced in Benin. *International Journal of Food Microbiology* 107, 304–309.

Beddows C.G. 1985. Fermented fish and fish products. in B.J Wood, ed. *Microbiology of Fermented Food*, Elsevier Applied Science publishers, London, pp1-39.

Communauté Economique Européenne. 1990. Proposition de règlement du conseil arrêtant les règles sanitaires régissant la production et la mise sur le marché des produits de la pêche. *Journal officiel des communautés européennes* C84, 33, 58-70.

Dakwa, S., Sakyi-Dawson, E., Diako, C., Takyiwa Annan, N. & Amoa-Awua, W.K. 2005. Effect of boiling and roasting on the fermentation of soybeans into dawadawa (soy-dawadaw). *International Journal of Food Microbiology* 104, 69-82.

Deng, F.H., Sheng, H., Chyuan, Y. & Chang, C.C. 1995. Biogenic amines in the flesh of Sail-fish (*Istiophorus platypterus*) responsible for *scombroid* poisoning. *Journal of Food Science* 60 (5), 926-928.

Essuman K.M. 1992. Fermented fish in Africa: a study on processing, marketing and consumption. FAO Fisheries Technical Paper 329, p80.

Food and Drug Administration 1982. Defect action levels for histamine in tuna. Availability of guide. Fed. Reg. 470:40-87.

Gram, L. & Dalgaard P. 2002. Fish spoilage bacteria-problems and solutions. *Current opinion in Biotechnology* 13 (3), 262-266.

Gram, L. & Huss, H.H. 2000. Fresh and processed fish and shellfish. in: B.M Lund, T.C. Baird-Parker, and G.W Gould, Eds. *The Microbiological Safety and Quality of Foods*. Aspen Publishers Inc., Gaithersburg, Maryland, USA, pp 472–506.

Horner W.F.A. 1997. Preservation of fish by curing (drying, salting and smoking). in G.M. Hall, ed. *Fish Processing Technology*, 2nd edn. Blackie Academic & Professional (Chapman & Hall), London, pp. 32-72.

Hounhouigan, D.J. 1994. Fermentation of maize (Zea mays L.) meal for mawè production in Benin: Physical, chemical and microbiological aspects, PhD thesis, Wageningen, p99.

Huss, H.H. 1988. Fresh fish: Quality and quality changes. Training manual prepared for the FAO/DANIDA. Training Program on Fish Technology and Quality Control. *FAO Fisheries Series* 29, Rome, p132.

Huss, H.H. & Valdimarson, G. 1990. Microbiology of salted fish. *FAO Food Tech. News* 10 (1), p190.

Kerr, M., Lawicki, P., Aguirre, S. & Rayner, C. 2002. Effect of storage conditions on histamine formation in fresh and canned Tuna. Food Safety Unit, State Chemistry Laboratory, Werribee, pp5-20

Kingley-Ekow, G.S. 1999. A study of the effects of handling, processing and storage on the histamine content in salted, fermented Tilapia. M. Phill thesis, University of Ghana, Legon, Accra, Ghana, p133

Metz, M. 1993. Starter cultures, their industrial manufacture for the meat industry. In Fleischwirtsch., English part 73 (12), pp1394-1396.

Nerquaye-Tetteh G.A., Eyeson K.K. & Tete-Marmon J. 1978. Studies on *momone*, a Ghanaian fermented fish product. *Ghana Journal of Agriculture and Science.* 11, 21-26.

Olympia, M.S.D. 1992. Fermented fish products in the Phillippines. in: *Application of Biotechnology to Traditional Fermented Foods*. National Academic Press, Washington D. C., pp 131–139.

Parkouda C., Nielsen D.S., Azokpota P., Ouoba L.I.I., Amoa-Awua W.K., Thorsen L.,Hounhouingan J.D., Jensen J.S., Tano-Debrah K., Diawara B. & Jakobsen M. 2009. The microbiology of alkaline-fermentation of indigenous seeds used as food condiments in Africa and Asia. *Critical Reviews in Microbiology,* 35 (2), 139-156.

Pearson, D. 1976. The chemical Analysis of Foods. 7th edn, Churchill Livingstone, Edinburgh, London and New York, pp387-497.

Sanni, A.I., Asiedu, M. & Ayernor, G. S. 2002. Microflora and chemical composition of momoni, a Ghanaian fermented fish condiment. *Journal of Food Composition and Analysis* 15, 577-583.

Shalaby, A. R. 1996. Significance of biogenic amine to food safety and human health. *Food Research International*, 29, 675-690.

Sefa-Dedeh, S. 1995. Traditional fish processes: Technology, quality and evaluation. In Workshop on Seeking Improvement in Fish Technology in West Africa. IDAF Technical Report, 66.

Sefa-Dedeh, S. & Youngs, A.J. 1976. The bacteriological quality of Ghanaian solar salt with reference to its use in fish preservation. *Ghana Journal of Science,* 16 (2), 7-13.

Steinkraus, K.H. 1991. *African alkaline fermented foods and their relation to similar foods in other parts of the world*. In A.Wesby & R. Stockholm, eds. Proceeding of a Regional Workshop on Traditional African Foods-Quality and Nutrition. International Foundation for Science, pp 87-92.

Vieira-Dalodé G., Jespersen L., Hounhouigan J., Moller P.L., Nago C.M. & Jakobsen M. 2007. Lactic acid bacteria and yeasts associated with gowé production from sorghum in Benin. *Journal of Applied Microbiology*, 103, 342-349.

Watanabe, K.O., 1982. Fish handling and processing in tropical Africa. In: Compte rendu de la consultation d'experts FAO sur la technologie du poisson en Afrique, Casablanca, Maroc. Rapports de la FAO sur la pêche 268, supl. pp1-5.

Yankah W. 1988. Studies on momone: a Ghanaian fermented fish product. B. Sciences thesis, Department of Nutrition and Food Science, University of Ghana, Legon, p80 .

Literature review and Background information

of

Gowé

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:

Adinsi, L., Vieira-Dalode, G. , Akissoe, N. and Hounhouigan, J.

Faculty of Agronomic Sciences, University of Abomey-Calavi

(Benin)

Edited by: Annali Jacobs

December 2010

Table of content

Abstract

Gowé is a traditional Beninese beverage made from malted and non-malted sorghum or maize flour. It is a fermented and sweet paste with specific aroma consumed after dilution in water. Sugar, ice or milk is added if wanted. It is originally produced in the centre of Benin, but nowadays sold also in Cotonou, Parakou and surroundings. Several studies performed in Cotonou and Parakou led to the identification of four production processes. The main operations characterizing original gowé production are malting, fermentation and cooking. From the four processes identified, one is a modified technology which does not contain the malting step. The characterization of the different products obtained showed that its pH is around 4 which limits the development of pathogenic micro-flora. The main sugars identified during gowé production are glucose and maltose. The dominant micro-organisms responsible of spontaneous gowé fermentation are lactic acid bacteria and yeasts. Some trials have been performed using the identified lactic acid bacteria as starter cultures to perform controlled fermentation. These studies aimed at obtaining gowé with an improved and reproducible quality. Gowé can be stored at 4°C with a maximum shelf life of around 8 days. More research is needed to standardize the malting, to control the fermentation and to improve the nutritional and organoleptic quality and shelf-life of traditional gowé.

Introduction

Gowé is one of the most popular products obtained traditionally from sorghum (*Sorghum bicolor (L.)Moench*) in Benin. Gowé is consumed as a beverage after the addition of sugar, ice and sometimes milk. It is traditionally obtained after three main operations namely malting, fermentation and cooking. The final product has a sour and sweet taste with specific aroma and texture. It is widely consumed in the urban areas of Benin by the children and the adults. The gowé produced from red variety of sorghum is the most popular with consumers. It is produced and sold in the main cities of Bénin (Bohicon, Cotonou and Parakou), especially during the hot periods and feasts such as Ramadan. It is presented to the consumer wrapped in leaves (*Thalia welwichii* or *Tecktona grandis*) or plastic material. During the past seven years, some research activities have been performed on gowé in Benin. This report gives an overview of the results obtained.

1. Traditional processing of the product

1.1. Raw materials and additives uses and their handling

The raw materials used to produce gowé are maize or sorghum. The gowé made from sorghum (*Sorghum bicolor (L). Moench*) is the most common in several cities of Bénin. The red variety is the most preferred by the consumers (Michodjehoun-Mestres et al., 2005). The kernel must be entire, not damaged, having a big size and being floury. Sorghum is cultivated mainly in the northern part of the country, but it is sold in all regions of Bénin and available in all markets.

1.2. Description and variability/similarity of processing methods

Several surveys carried out in different parts of the country have led to the identification of at least three types of traditional processes and one modified technology. The main unit operations characterizing the traditional technologies are malting, fermentation and cooking (Michodjéhoun-Mestres et al.., 2005, Glidja et al.., 2006, Vieira-Dalodé et al.., 2007). The modified technology is encountered in some cities and in that case the gowé is produced without the malting step (Michodjéhoun-Mestres et al.., 2005).

According to Michodjehoun-Mestres et al.. (2005), following the traditional process, the sorghum grains are cleaned and soaked overnight about 16 hours) at local room temperature (28-30°C). The soaked grains are drained and left for germination at room temperature (28-30°C) for 2 days. The germinated grains are sun-dried (4 days) and milled to obtain the malted sorghum flour. A part of this flour is mixed with non-malted sorghum flour and water. The mixture is left for a first fermentation of 12h at room temperature (28-30°C). The fermented paste is mixed with a porridge made with the rest of the non-malted sorghum flour. A second fermentation of 24 to

48h is carried out. After that, the fermented mixture obtained is cooked at 100°C f or 30 min (figure 1).

A survey carried out at Parakou, in the north of Benin, identified another traditional process in which the germinated sorghum grains are mixed with non-germinated sorghum (Glidja et al., 2006. The mixed grains are milled. One part of the flour is kneaded with water and left to ferment for 10 to 72 h. The rest of the flour is used to make a porridge which is mixed with the fermented paste and left to ferment again for 7h. The fermented mixture is cooked to produce gowé (figure 2).

Vieira-Dalodé et al.., (2007) identified a third traditional process in Cotonou. The grains are cleaned and divided into two parts. One part (25%) is soaked, germinated, sun dried and milled. The malted sorghum flour obtained is kneaded with water and undergoes a first saccharification/fermentation of 12h. The rest of the grain (75%) is milled. A part of the flour is used to make hot slurry which is then mixed with the fermented product with the rest of the non-malted flour with water and left for a second fermentation for 12 to 24h. The fermented product is cooked to obtain gowé (Figure 3).

The gowé obtained by the traditional processes are characterized by a natural sweet taste and a soft texture. The major constraints noticed are the time needed for malting and the skill required to perform it.

In Cotonou (south of Benin) a modified technology is practiced lately whereby gowé is produced by fermentation of non-malted sorghum flour for 72 h and adding commercial sugar to obtain the traditional sweet taste (Figure 4), (Michodjèhoun-Mestres et al.., 2005). Sometimes the supernatant of a previous production is used to reduce the fermentation time from 72 to 24h. The time required to produce the modified gowé is 3 days compared to 6-8 days for the traditional processes requiring malting of cereal grains.

The equipment used for gowé production is plastic buckets, baskets, a mill and leaves *(Thalia welwichii* or *tecktona grandis*)

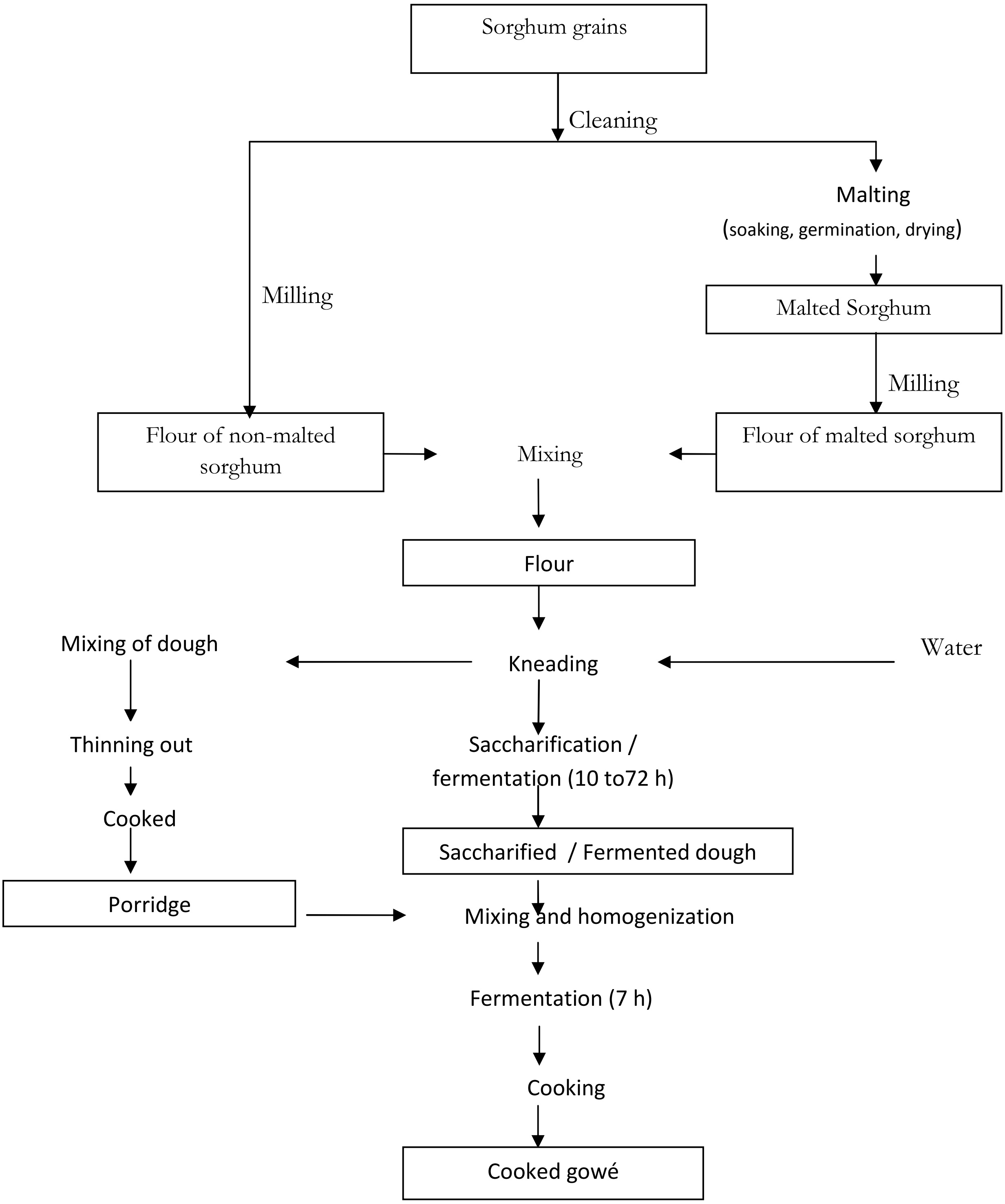


Figure 2: Flow sheet of gowé production (Glidja et al., 2006)

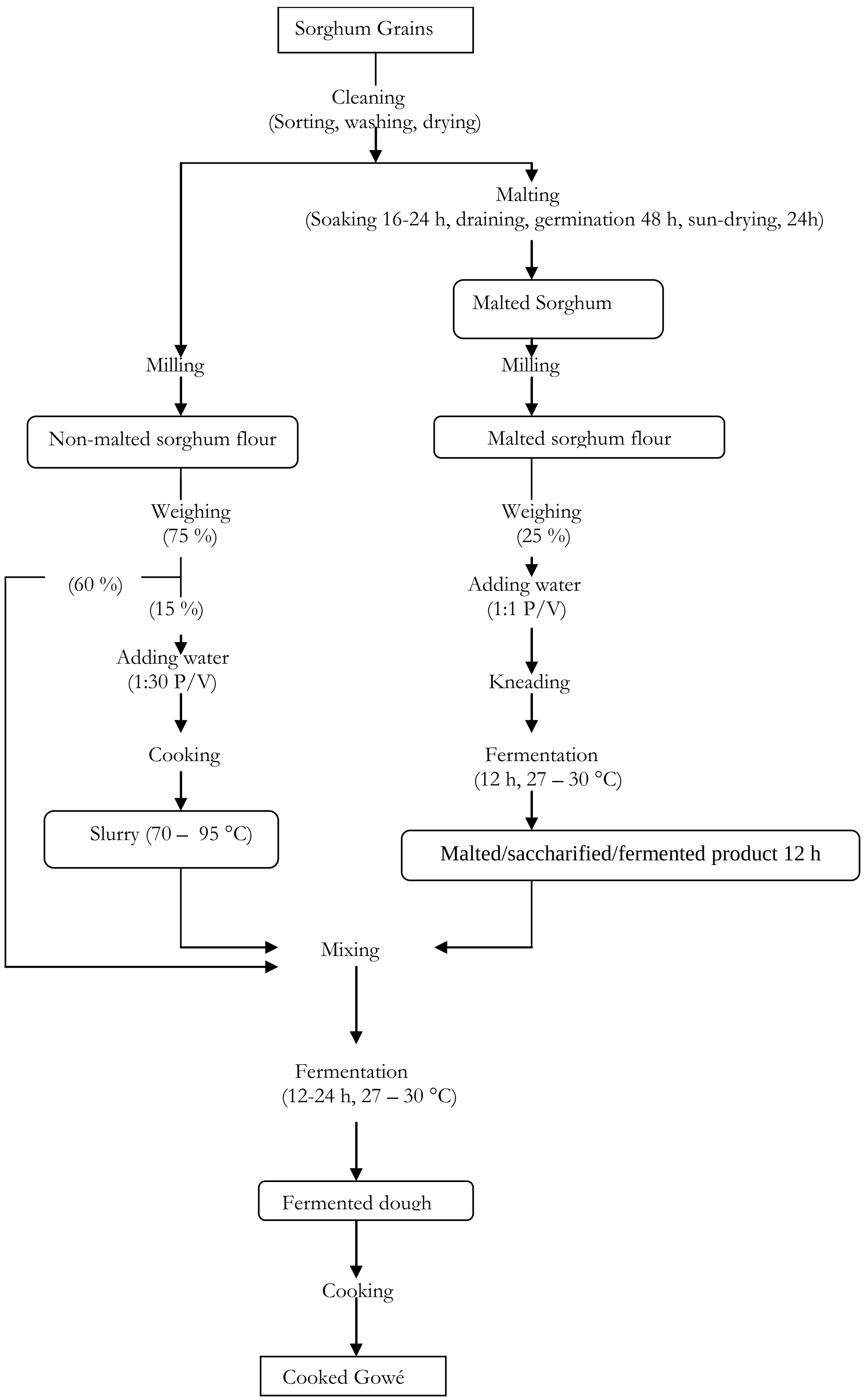


Figure 3: Flow diagram of gowé production "TSG" (Adjigbey-Tasas,2003; Vieira-Dalodé et al.,2007)

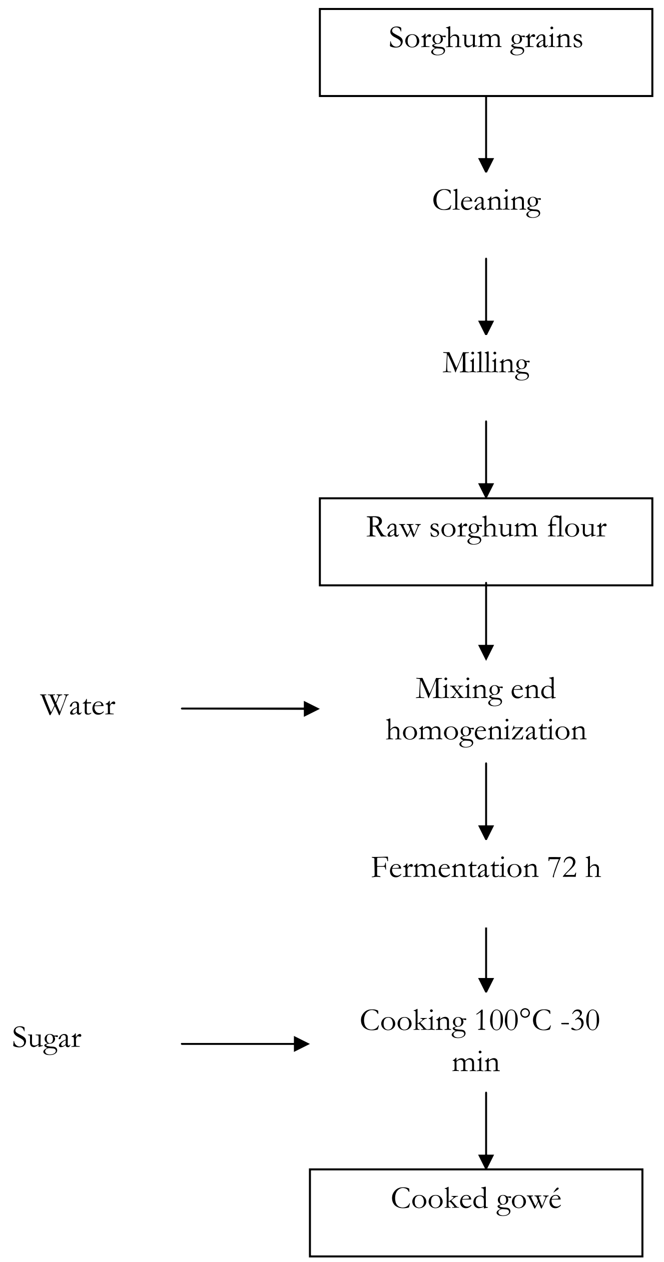


Figure 4: Flow sheet diagram for the production of modified gowé (Michodjèhoun-Mestres et al., 2005)

1.3. Major problems associated with processing methods

The major problems with the gowé production following the traditional processes are linked to the malting step and the control of the fermentation. The malting of sorghum grain is done without any control on the parameters which can affect the malting (moisture, temperature, etc). Consequently, the malting duration is variable and affects the functional properties of the malt.

The sun drying of the germinated grain depends on the weather, mostly the intensity of the sunshine. Furthermore, either during soaking, germination or drying, the grain can be subjected to contamination by fungi with potential development of high levels of mycotoxins (aflatoxins) (G. Fliedel, personal communication). The fermentation is initiated by the microorganisms of the environment (vessels, grains, etc) and consequently, is not controlled. Depending on the technology, high variability is noticed on the physico-chemical characteristics of the products. (Michodjehoun-Mestres et al., 2005; Vieira-Dalode et al., 2007).

1.4. Storage methods, maximum duration and problems associated with storage

Another constraint is related to the shelf-life of the product. The cooked gowé has a water content of 78.4% (Michodjehoun, 2000). Combined with the fact that the cooked gowé is packaged in leaves, sometimes under non-hygienic conditions, this high moisture content does not ensure a long shelf-life and the safety of the product. According to Michodjehoun-Mestres et al., (2005), gowé can be stored for two to three days at ambient temperature and up to one week at +4°C.

2. Socio-economic importance

2.1. Production, processing, handling and storage identified in the country

The different investigations done up to now (Michodjehoun, 2000; Glidja et al., 2006; Vieira-Dalodé et al., 2007) concluded that gowé is produced and sold in some cities of Bénin like Cotonou, and Parakou. This constitutes an income generating activity for many women. About 20 Gowé producers/sellers have been identified in Cotonou in 2006, distributed in different zones in the town (Table 1), with 14 producers using malt-based technologies. Gowé is also known as "sifanou" at Parakou. Eight (8) gowé sellers have been identified at Parakou (Table 2), all of them being of the "Idatcha" socio-cultural group.

Table 1 : Distribution of Gowé sellers in Cotonou

Sales Point	Gowé sellers	
	Number	Percentage (%)
Sacré-coeur	7	35
Fidjrossè	1	5
Gbégamey	8	40
St Rita	3	15
Godomey	1	5

Total	20	100

Table 2 : Distribution of Gowé sellers at Parakou

Sales point	**Gowé producers**	
	Number	Percentage (%)
Wansirou	7	87,5
Amanwingnan	1	12,5
Total	8	100

Gowé production in Cotonou and Parakou is estimated to about 230 tons, with 210 tons (91%) produced at Cotonou and 20 tons at Parakou.

There is a need to do some investigations on gowé production and handling in the center part of Benin which seems to be the region of origin of traditional gowé.

2.2. Socio-economic profile of the actors

A socio economic study was carried out to determine the actors in the gowé chain through the Malto-Sorghum project funded by DURAS (Agropolis, France). The production and the commercialization of gowé are traditionally activities performed by women. The incomes are generally used to provide in the needs of the family. The production of gowé is mostly performed in Cotonou by the Fon socio-cultural group, but also by the Mahi, the Goun and the Yoruba. In Parakou the socio-cultural group involved in gowé production is the Idatcha.

Gowé consumers are in different groups depending on the town (Fig. 1 & 2): traders, civil servants, workers, pupils or students, peasants, etc..

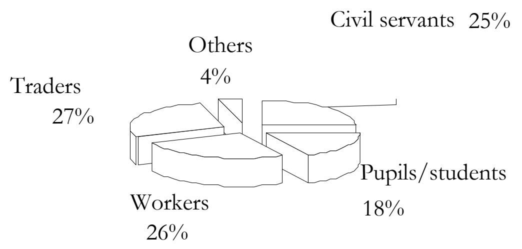


Figure 1: Distribution of gowé consumers among social groups in Cotonou

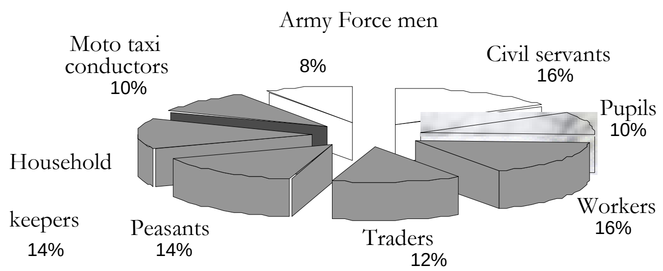


Figure 2: Distribution of gowé consumers among social groups in Parakou

2.3. Socio-economic importance of the product

During the hot period of the year, a high demand of gowé is observed. The product is consumed by many people (children and adults) and is sold per ball of 128-170g costing 50 FCFA while smaller quantities of 73-80g is sold at 25 FCFA. The women monthly income can be about 37905 FCFA (Michodjehoun, 2000).

2.4. Commercialization of the product

.After cooking the gowé is wrapped in leaves (*Thalia welwichii* or *tecktona grandis*) or plastic material in the form of a bowl of 75 or 175 g. The product is sold in many cities of Benin as a paste for the preparation of ready-to-use beverage. Sales take place in the markets, along some main roads.. Optionally it can be sold as ready-to-drink beverages after dilution in water with added sugar, milk and ice.

3. Quality characteristics of the product

3.1. Nutritional quality

Up to now few research studies have been conducted on the nutritional quality of gowé (Table 3). Some nutrients, essentially proteins (11.3 % dry basis) and lipids (1.6%), have been determined (Michodjehoun, 2000). Otherwise the malting and fermentation performed for gowé production may have an important effect on nutrient levels, by reducing some anti-nutritional factors (phytates, polyphenols) and enhancing the bioavailability of some micro-nutrients. The fermentation and the malting processes involved in gowé production may have made it a product rich in micro-nutrients like iron, zinc, the B vitamins, A, C and E which availability may have been improved (Traoré *et al.*, 2003).

3.2. Microbiological quality

Several studies have been done on the microbiological characteristics of gowé (Michodjèhoun, 2000; Sossa, 2001; Adjibey-Tasas, 2003; Zohoungbogbo, 2004; Michodjehoun-Mestres et al., 2005; Vieira-Dalodé et al., 2007).

Michodjehoun-Mestres et al. (2005) showed that the micro-organisms present in the gowé are the lactic acid bacteria, yeasts and moulds. According to these authors the microbial count of uncooked gowé after 72h of fermentation is 9 log (CFU/g) and 8,7 log (CFU/g) respectively for the lactic bacteria and yeasts and moulds. Vieira-Dalodé et al. (2007) found in the non-cooked gowé after 24 h of fermentation a count of 9,9 log (CFU/ml) and 5,1 log (CFU/ml) respectively for lactic acid bacteria and yeasts.

Previous works showed that the dominant lactic acid bacteria involved in gowé production are *Lactobacillus fermentum, Weissella confusa, Lactobacillus mucosae, Pediococcus acidilactici, Pediococcus pentosaceus* and *Weissella kimchii*. The yeasts are *Kluyveromyces marxianus, Pichia anomala, Candida krusei* and *Candida tropicalis* (Vieira-Dalodé et al., 2007). Some laboratory trials have been performed to use the identified lactic acid bacteria singly or in association with the yeast for a controlled fermentation (Vieira-Dalodé et al., 2008). The acidic pH of gowé may contribute to the reduction of development of the pathogens.

3.3. Physico-chemical and sensory characteristics.

The studies carried out by Michodjehoun (2000) showed that the gowé bought in markets is a product with high water content. The fermentable sugars in the product are by order of importance, glucose and maltose, whereas the main organic acids are lactic acid and acetic acid. Table 3 shows some physico-chemical characteristics of the gowé from sorghum available in the market.

Table 3. Some physico-chemical characteristics of the sorghum-based gowé sold in the market

Parameters	Mean values
pH	3,8
Titratable acidity (% db)	3,8
Water content (% wb)	78,4
Proteins (% db)	11,3
Lipids (%db)	1,6
Ash (% db)	1,9
Crude Fibre (% db)	1,7
Carbohydrates (% db)	83,5
Total sugars (% db)	3,2

db: dry basis wb: wet basis

Source : Michodjehoun (2000)

The different aromatic compounds identified in gowé are alcohols, acids, esters, aldehydes, hydrocarbons, furans and phenol (Vieira-Dalodé, 2008). All these compounds have been identified at the beginning of the fermentation and may have been produced during malting.

3.4. Product quality perception/requirement by consumers

According to Michodjehoun-Mestres et al., (2005) consumers prefer gowé of intermediate texture, one that holds together, but does not resist to finger pressure. When consumed, the gowé should not stick to the fingers, the teeth or the roof of the mouth; it should simply melt in the mouth.

4. Consumption forms of the product

4.1. Food forms

Gowé is sold in the form of a soft paste which is further consumed diluted in water with the addition of ice, sugar and milk according to tast (Michodjèhoun, 2000). Some people consume it without dilution.

4.2. Period of the day for consumption

Gowé is consumed as a thirst quenching beverage mainly during the hot periods. It is also frequently used to stop fasting, mainly during Ramadan.

5. Research activities and new development on technology and product

5.1. Comparisons of different technologies of gowé processing

A study was performed to compare two sorghum-based traditional technologies using malted sorghum (Fig. 1 & 3), in terms of the hygienic, nutritional and sensorial qualities of the product. This study showed that the titratable acidity, the total phenols content, the total cyanide contents, are not affected by the technology, but that the yield, the pH, the total sugar content, and apparent viscosity are significantly affected by the technology used. The organoleptic characteristics of the two types of cooked gowé are significantly different. Gowé from TSG technology were found to be sweeter, more consistant, aromatized and consequently more popular than gowé from TSM (Adjigbey-Tasas, 2003).

Another study was performed to compared the TSG technology to the TNSG technology (Figure 4) (Zohoungbogbo, 2004), using the same quality characteristics as previously. The results of this study can be summarized as follows:

- The dry matter yield of the TSNG (95,7 %) at 12 hours of fermentation is higher than that of TSG (89 %) after 24 hours of fermentation.
- The TSG product showed higher sugar content and lower viscosity values than the TSNG product irrespective of the time of fermentation. Moreover, TSG product showed higher a pasting temperature and total phenols concentration values. Nevertheless, total phenol content of the TSG at 24 h of fermentation is similar to the one of TSNG at 12 h of fermentation.
- Phytate concentrations decrease during fermentation in both technologies.
- There was no significant difference between the product of 24 h fermentation obtained from the TSG and the product of 12 h fermentation from the TSNG processes in terms of the pH, the titratable acidity, the phytate and total phenols concentrations.
- The cooked " gowé " obtained from these technologies had the same taste, the same sweetness and similar aroma (flavour). However, the lower viscosity of the "gowé" from the TSG process makes it more acceptable by the "gowé" panelists.
- Finally, among 3 of the 4 technologies identified, the TSG technology was found as the most promising in terms of both nutritional and sensorial quality.

5.2. Using decorticated and non malted sorghum to improve gowe quality

Some trials were conducted to improve the nutritional quality of gowé using decorticated sorghum grain (Houndélo, 2004). The results revealed that when the non-malted part of sorghum is decorticated, there is a decrease of phytates (67%, bs) and total phenol (42%, bs), but no significant modification of pH, titratable acidity, solubility, swelling capacity and pasting temperature was observed. Nevertheless, viscosity of the decorticated product became significantly higher ($P<0.005$). Furthermore, sensorial characteristics were improved due to the decrease of astringency. Gowé from decorticated sorghum was then prepared in two forms: (1) cooked gowé that is directly diluted into porridge (liquid form) and cooked gowé flour obtained by drying the fermented and cooked paste. Traditional gowé was used as control for comparison. The physico-chemical and sensorial evaluations showed that all gowé were similar as far as sourness and sweetness were concerned. The new forms were all acceptable and equally popular. However, the drying temperature (80°C) of the cooked gowé flour was reduced to 70°C, because the higher temperature induced a burning smell and taste in the product. The yoghurt-like gowé obtained from the liquid form can be conserved at 4°C during 8 days. The market survey revealed that gowé, its packaging as well as its commercial name were accepted by larger part of the people investigated (more than 75% obtained versus 30% for expected). The market survey showed that most (more than half) of the people interviewed agreed upon the price (100F CFA) that can enable the producer to make a small profit.

Recently, a study was undertaken to improve the traditional technology of gowé production and the shelf-life of the product by using the TSG technology. The effect of three main parameters (the moisture content of the substrate during fermentation, the fermentation time and the drying temperature of the non-cooked product) on gowé quality was evaluated. The main findings were that:

- The pH and the titratable acidity were significantly different when gowé was dried after 24 h of fermentation as opposed to after 48 h.
- The pH and titratable acidity of the product dried after 48h of fermentation are very similar to those of the traditional gowé.
- The physico-chemical characteristics of the products dried at 70°C after 48 h of fermentation were similar to those of traditional gowé, irrespective of the initial water content.
- The best characteristics were obtained for gowé fermented for 48 h and dried at 70°C with an initial water content of 58,6 %. This type of gowé was preferred by 80% of the panel.

5.3. Controlled fermentation of Gowé

Lactobacillus fermentum, Weissella confusa, Kluyveromyces marxianus and *Pichia anomala* previously isolated during natural fermentation of traditional gowé (sorghum beverage) were tested for their ability to be used as starter cultures for controlled fermentation of gowé. The characteristics of the final product were evaluated by chemical analysis and sensory evaluation. Determination of colony forming units and molecular biology techniques were used to verify growth of the starter cultures used. Significant decrease of pH with concomitant increase of titratable acidity was observed after 24h of fermentation when the lactic acid bacteria (LAB) starter cultures were used alone or in association with any of the yeasts. The LAB count increased significantly while yeast count remained constant throughout fermentation. Patterns obtained from Rep-PCR performed on isolates during the fermentation, confirmed dominance by the LAB added as starter cultures. A sensory evaluation revealed that the product fermented for 7h with *L. fermentum* alone or in association with *K. marxianus* was as acceptable as the traditional product normally obtained after a minimum of 24h of fermentation. Consequently, gowé with stable quality obtained by controlled fermentation, can be envisaged in small scale industry.

Conclusion

Important research activities have been carried out on gowé. This report gives an overview on the socio-economic importance of the product, mainly at Cotonou and Parakou. It also gives an overview of the variability of the technologies and of the quality of the products. Some research activities have been performed to upgrade the technology. However, more research is needed to confirm the results obtained. Furthermore, there is a need for more investigations on the variability of the technology at the center of the country (Zou-Collines), to improve the processing and the nutritional and organoleptic quality of the product through decortication of a part of the sorghum grain, standardization of the malting process, control of the fermentation and improvement of the shelf life of the product by drying and better packaging of the non-cooked or cooked gowé.

References

1. Adjigbey-Tasas, R. 2003. Contribution à la valorisation des aliments traditionnels béninois. Etude comparative de deux technologies à base de sorgho malté pour la production de "gowé". Thèse ingénieur FSA/ UAC.
2. Glidja M., Madodé Y.E., Goussanou J., Vieira-Dalodé G. & Hounhouigan D.J. 2006. Identification des technologies de production de gowé et leurs contraintes à Parakou et à Cotonou. Rapport d'enquêtes. ?
3. Houndélo Monia (2004). Amélioration de la qualité et test de mise en marché du gowé, pâte fermentée à base de sorgho. Mémoire de fin d'étude d'Ingénieur Agro-alimentaire. Institut National Polytechnique de Bouaké et Faculté des Sciences Agronomiques (UAC).
4. Michodjehoun L. (2000). Système technique et caractérisation du gowé, une pâte fermentée à base de céréale. Thèse d'ingénieur. Université Nationale du Bénin. FSA
5. Michodjèhoun-Mestres L., Hounhouigan D.J., Dossou J. & Mestres C. 2005. Physical, chemical and microbiological changes during natural fermentation of *Gowe*, a sprouted or non sprouted sorghum beverage from West-Africa. *African Journal of Biotechnology* 4 (6), 487-496.
6. Traoré T., Mouquet C., Icard-Vernière C., Traoré A.S. & Trèche S. 2003. Changes in nutrient composition, phytate and cyanide contents and alpha-amylase activity during cereal malting in small production units in Ouagadougou (Burkina Faso). *Food Chemistry*, 88 : 105-114.
7. Sossa, C. 2001. Caractérisation et identification de la microflore de fermentation du gowé, une pâte fermentée à base de sorgho. Thèse d'ingénieur. Université d'Abomey-Calavi. FSA.
8. Vieira-Dalodé G., Jespersen L., Hounhouigan J., Moller P. L., Nago C.M. & Jakobsen M. 2007. Lactic acid bacteria and yeasts associated with gowé production from sorghum in Benin. *Journal of Applied Microbiology,* 103 342-349.
9. Vieira-Dalodé G., Madode Y.E., Hounhouigan J., Jespersen L., & Jakobsen M. 2008. Use of starters cultures of lactic acid bacteria and yeasts as inoculum enrichment for the production of gowé a sour beverage from Benin. *African Journal of Microbiology Research* **2** : 179-186.

10. Vieira-Dalodé G. 2008. Fermentation de la farine de sorgho pour la production de Gowé au Bénin (Aspects chimiques et microbiologiques). Thèse de Doctorat Unique. Université d'Abomey-Calavi, Bénin.
11. Zohoungbogbo M.-A. 2004. Etude de deux technologies de production de gowé à base de sorgho. Thèse d'ingénieur. Université Nationale du Bénin. FSA.

Literature review and Background information of *Jaabi*

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:

Ndjouenkeu, R. and Biyanzi, P.

ENSAI (Cameroon)

Edited by: Annali Jacobs, Joseph D. Hounhouigan

December 2010

Table of Contents

Abstract

Ziziphus mauritiana, a tree of *Rhamnacea* family, locally called *Jaabi* in northern Cameroon, is spread in the Sahelian region of Africa, but has not attracted scientific and technological interest in spite of its significant use by local populations. Studies performed on the chemistry and technology of the *Ziziphus* fruits are focused on Indian and Chinese products. The present review investigates the expansion of *Ziziphus* in the world and in African markets, with emphasis on its processing practices in Cameroon. The chemical and biological composition and properties of the African variety of *Jaabi* compares favourably to the Indian and Chinese fruits, both for nutritional and medicinal applications. Research questions and hypotheses are then raised about three issues: *i)* the relation between the above properties and indigenous processing practices in the preparation of a local cake, *Yaabande*; *ii)* the valorisation of *Jaabi* through the formulation of nutraceutical foods involving antioxidant components, abundant in the fruits; *iii)* and the exploitation of the intense and pleasant biscuit-like flavour of the fruit in bread-making, using composite flours containing *Jaabi* powder or aroma extracts. The scientific validation of the above hypotheses may raise the agricultural and economic interest in *Jaabi* and facilitate its agricultural development with advantages for the producing farmers in terms of improvement of their incomes, poverty reduction and nutritional status.

Introduction

The jujube tree, a species belonging to the genus *Ziziphus* and the family *Rhamnaceae,* is widely spread in the tropical and subtropical regions of Asia, Africa, and Australia (Figure 1). This plant originated from central Asia (Aubréville, 1950), its exact date of introduction in Africa is uncertain. The name *Ziziphus* is related both to an Arabic word, *Zizoufo*, used along the North African coast, and to the ancient Persian words, *zizfum* or *zizafun*; and also to the ancient Greek word *ziziphon* (Azam-Ali *et al.*, 2006).

An important number of *Ziziphus* species have been described, varying from 86 species (Evreinoff, 1964; Johnston, 1972) to 135 (Bhansali, 1975), or even 170 (Liu and Cheng, 1995), with multiple names, many of them corresponding just to synonymy, depending on the taxonomist's view of a species. This variability has been the subject of a review by Azam-Ali *et al.* (2006), who emphasized the fact that *Ziziphus* fruits are an "*integral part of the culture* *and way of life of millions of diverse Asian people and have become so for large regions of Africa*",

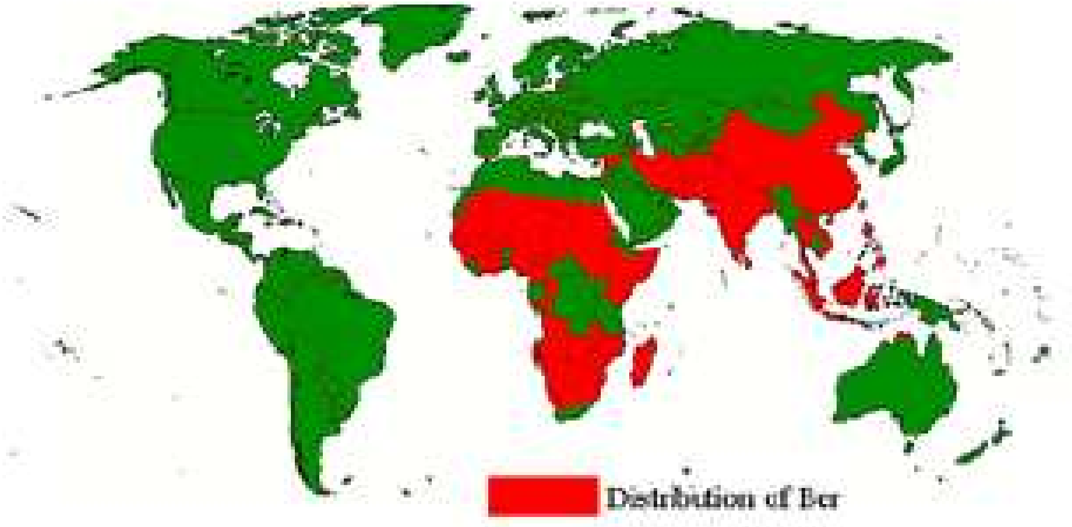


Figure 1: Distribution of jujube tree in the world (Pareek, 2001).

The two major domesticated jujubes, cultivated over vast areas of India and China, are *Z. mauritiana* Lam, the Indian jujube or ber, and *Z. jujuba* Mill, the Chinese or common jujube. These species have been introduced in Africa where they coexist with minor cultivated or wild species.

In Africa, *Ziziphus* is currently found in Soudano-Sahelian savannah regions, where it grows as wild plants on any type of soil, preferably near temporary rivers (Seignobos & Olivry, 2000 ; Arbonnier, 2002). The main species of jujubes found in Africa are *Z. mauritiana*, *Z. spina chriti*, Z *abyssinica* and *Z. mucronata*. *Z. mauririana* represents the most common specie largely consumed and used in food, therapeutic and social practices in many regions. Table 1 gives some local names of *Ziziphus* in different African languages.

In Cameroon, it is only found in the northern part of the country, in the mountainous regions of Logone Birni and Rhumsiki.

The tree of *Z. mauritiana* is 7-12 m in height and the trunk is 30 cm in diameter. Branches are slender and downy, bearing paired, brown spines; one straight and the other slightly hooked. It has a wide spreading crown and a short bole. It is a fast growing tree, with an average bearing lifespan of 25 years. The fruits, locally known as *Jaabi* in Cameroon, are variable in shape, colour and size. Round, oval or oblong in shape, the fruits may be brownish, reddish or violet/purple in colour (Figure 2). Wild fruits are 1.5 - 2.5 cm in length and 1-2 cm in diameter. However fruit of improved cultivars, developed in India and China, can be up to 5 cm in length.

Table 1: Local African names of *Ziziphus*

Country	Language	Vernacular name
Cameroon	Fulfulde Guiziga Kapsiki	Jaabi Hilvid Ndova
Nigeria	Haoussa	Magaria
Mali	Bambara Madingue	Ntomono Tôbôrô
Zaïre	Swahili	Mkunazi
Zimbabwe	Shona	Musawu
Sénégal	Wolof	Sidem
Kenya	Swahili	Mkunazi
Ethiopia	Tigre	Gewa-ortigi
Malawi	Chewa	Masawo
Tanzania	Swalihi	Mkunazi
Uganda	Karamajong	Esilang
Zambia	Nyanja	Masau

Young fruits (brownish variety) | **Dry fruits (brownish variety)** | **Mature fruits (violet variety)** | **Dry fruits (reddish variety)**

Figure 2: ***Ziziphus mauritiana* fruits**

1. Traditional processing of *Z. mauritiana*

1.1. Overall traditional food processing of *Ziziphus* in Africa

Ziziphus fruits are used for processing of different products, particularly in India, which provides the wide platform of processed and referenced products from fresh and dry fruits (Table 2). In Africa, only the pulp of dry fruits is used in food processing. The pulp is pounded into flour which is then processed in different traditional products varying from one region to another. The *Ziziphus* powder is currently used as famine food in Niger (Williams, 1998), and for the preparation of local cakes called « Ntomononfléni » in Mali (Penda and Alpha, 2002) or "Yaabande" in Cameroon (Noyé, 1989). Cakes are made out of dried and fermented pulp in western Sudan (Dalziel, 1937), and in Zambia (Kalikiti, 1998). The Touareg nomads in Mali make flat bread from dry fruit pulp using wild species (Chevalier, 1947). In Zimbabwe, the *Z. mauritiana* flour is also processed for jam (Maposa and Chisuro, 1998), traditional loaf (Kadzere, 1998) and "kachaso", a crude spirit (Arndt & Kayser, 2001). An alcoholic drink is made in Malawi with wild *Z. mauritiana* fruits.

Table 2: Main food processing of *Ziziphus* fruits

	Processing forms	**References**
Fresh fruits (India)	Candy, jelly, beverage, nectars, compotes	Munier (1973) ; Pareek & Vashishtha (1983) ; Maposa & Chisuro. (1998) ; Pareek (2001) ; Rathore (1986), ICUC (2002).
	Alcoholic beverages	Khurdiya & Singh (1975) ; Chivero & Mawadza. (1998) ; Pareek (2001) ; Rathore (1986) and ICUC, (2002).
Dry fruits (Africa & India)	Raw or powder	
	Traditional bread	Chevalier (1947) ; Kadzere (1998).
	Cakes	Munier (1973) ; Kalikiti (1998) ; Arbonnier (2002) ; Penda & Alpha (2002) ; Pareek (2001); Rathore (1986), ICUC (2002).
	Dessert and cream	Cheema et al. (1954) ; Munier (1973) ; Pareek (2001) ; Rathore (1986), ICUC (2002).
	Beverage	Vivien & Faure (1995)

1.2. Variability of processing methods of *Jaabi* in northern Cameroon

Yaabande, a round biscuit-like product, is the main processing form of *Jaabi* in the northern part of Cameroon. The methods of preparation vary from one tribe to another. Kapsiki, Guzigua and Kanuri are the main tribes processing the fruit. The *Jaabi* powder is obtained from the dry fruit by pounding in a mortar and sieving. Then, four main practices are used to process the powder in *Yaabande* after sprinkling it with water and molding (Figure 3).

The Kapsiki tribes wrap the molded paste in vegetable leaves and cook it directly in the fire for about 30 min. (Fig. 3a) The Guiziga compact the paste in small calabashes which are set in a cooking pot containing water, and the paste is cooked by vapor for about 30 min. (Fig (3b). The Kanuri sundry the molded paste for about 12 hours, either after compaction in small calabashes (Fig. 3c) or wrapping in vegetable leaves (Fig. 3d).

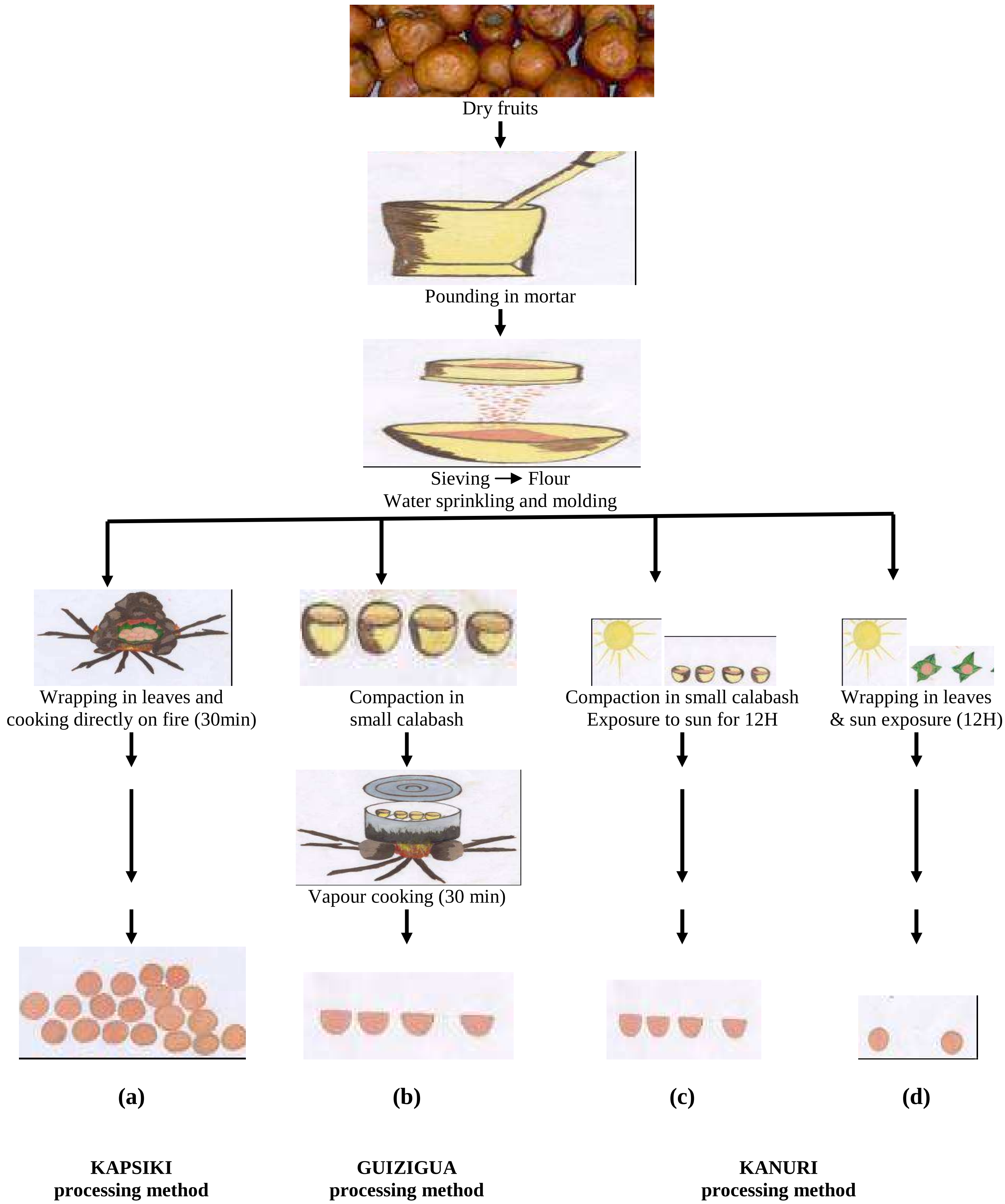


Figure 3: Traditional processing methods of *Jaabi* in the northern region of Cameroon

1.3. Major problems associated with processing methods of *Jaabi* into *Yaabande*

It could be assumed that the variability of the traditional processing methods of *Jaabi* results in variability of the *Yaabande* quality, both from a composition and hygienic point of view. In this respect, the Kapsiki method, based on direct cooking or roasting of *Jaabi* paste in fire, raises the question of the risk of heat degradation of the nutrients. In addition, since the Guiziga and Kanuri processing methods present fewer risks for nutrient degradation, the amount of residual water in the product has not been studied and may constitute a favorable medium for the development of microorganisms during storage. This risk is potentially greater with the Kanuri processing method by which the *Jaabi* paste molded in a calabash is sundried without protection. In this case, the product is exposed both to dust and aerial microorganism contaminations.

In general, the pounding procedure does not care about eliminating the fruit pellicle which may contain anti-nutrients, as observed in many vegetal structures.

1.4. Storage methods, maximum duration and problems associated with storage

Jaabi dry fruits are stored, at room temperature, in polythene bags or in calabashes after harvesting, and the powder in plastic bags or calabashes. *Yaabande* is sold as such on market stands or in dishes. The storage of dry fruits runs from November to March or April, which corresponds to the harvesting period, while the powder is usually stored for longer period (6 – 12 months) depending on the availability. *Yaabande* can also be stored for longer periods, depending on the market.

No scientific study exists on the storage conditions or on the quality of fruits, powder and *Yaabande* during storage. Since the main production, processing and marketing period of *Jaabi* is during the dry season, this may explain why product degradation is not usually observed on markets. However, the risks of mite infestation or microbial contamination should be taken into consideration, especially in view of the local and non-standardised methods of conservation.

2. Socio-economic importance of *Jaabi*

2.1. Production, processing, handling and storage zones identified in the country

The production and processing area of *Jaabi* cover the savannah region of Cameroon, in the northern part of the country (Fig. 4). This area represents also the main consumption zone of the product. The fruits and even the processed product can be found in other areas of the country, due to migration of populations from the northern part, who conserve their tribal food habits.

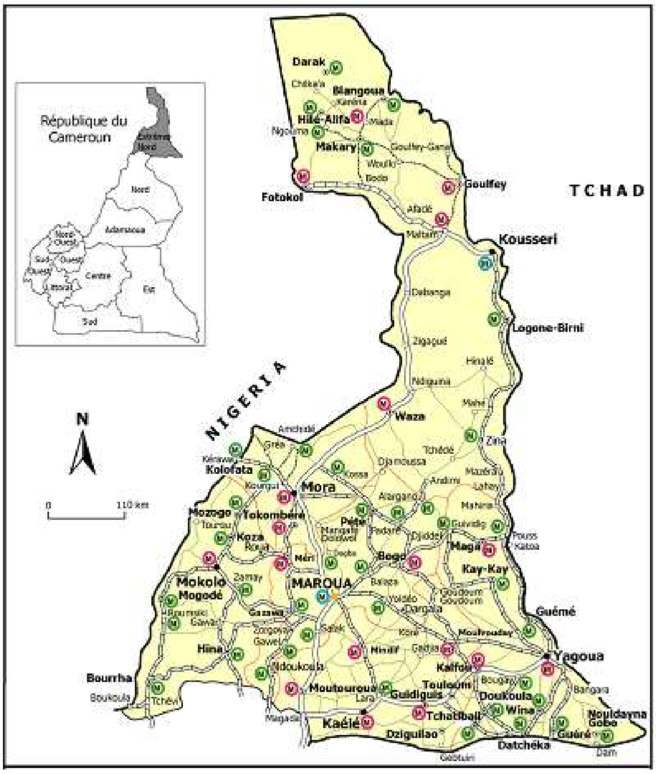


Figure 4 : Production and processing area of *Jaabi* in Cameroon

2.2. Socio-economic profile of the actors (processors and retailers)

Jaabi processing is an indigenous practice of savannah populations. Its consumption and use can be linked to the culture of these populations, mainly constituted of shepherds. It is usually eaten as side dish by shepherds when they are out with their flocks. In addition, the fruit is defined as food for kids when guarding goats and sheep, and can constitute part of their usual diet if available in good quantity (Mignot, 2000, cited by Igor De Carine, 2002).

The processing into *Yaabande* and its marketing are essentially activities performed by women.

2.3. Socio-economic importance and commercialization of *Jaabi*

Jaabi is a typical traditional local food, consumed exclusively by savannah populations as side dish. Its market is essentially local, particularly in areas inhabited by a significant number of population originating from the savannah region of the country. Its contribution to food security has not really been evaluated. Meanwhile, since the fruit is harvested and processed during the dry season, a period characterized by a significant risk of food starvation, it can be considered as a significant contributor to food security during that period. The processing of the fruit into *Yaabande* represents a form of conservation of the product which is consumed throughout the dry season, and even thereafter.

3. Quality characteristics of *Jaabi*

3.1. Nutrient content

The richness of *Ziziphus* pulp in nutritive compounds has been widely recognized, particularly for the Indian and Chinese jujubes (Table 3). These fruits have interesting contents of carbohydrates, minerals (calcium, phosphorus, iron), β-carotene and vitamins C and P (bioflavonoid). Major scientific interest has focused on the vitamin C and P contents of jujube pulp, considering their biological and synergetic properties (maintenance of capillary walls, antibacterial, antioxidant, stimulation of bile production, prevention of allergies) (GreatVista Chemicals, 2004). Baratov *et al.* (1975) found, in some *Ziziphus* fruits, 188 to 544 mg Vitamin C and 354 to 888 mg Vitamin P per 100 g of pulp. Troyan and Kruglyakov (1972) and Ahmedov and Halmatov (1969) reported even higher contents of these vitamins: up to 811 $mg.100g^{-1}$ and up to 1230 $mg.100g^{-1}$ respectively for vitamin C and vitamin P.

In general, data on the nutrient content of *Ziziphus* vary greatly among authors, due, certainly to the variability of *Ziziphus* species and methods of analysis. In addition, data on the nutrient contents of African varieties are relatively scarce. This assessment suggests the necessity to investigate African *Ziziphus* for comparison with Indian and Chinese varieties. Preliminary studies of *Z. mauritiana* from the northern part of Cameroon (Biyanzi 2006) have confirmed significant amounts of carbohydrates (28 – 34%, DM basis), minerals (Fe: 1.6 – 2 $mg.100g^{-1}$ DM; Ca: 63 – 86 $mg.100g^{-1}$ DM; P: 59 – 69 $mg.100g^{-1}$ DM), vitamin C (81 – 92 $mg.100g^{-1}$ DM), vitamin A (20 – 26 $\mu g.100g^{-1}$ DM) and polyphenols (0.4 – 0.6 %, DM basis) in the pulp (Table 4)

Table 3: Summary of some nutrient content of Indian and Chinese *Ziziphus* (100 g DM)

Nutrients	**India**		**China**
	Morton (1987)	Pareek (1983;2001)	Troyan & Kruglyakov (1972), Baratov *et al.*, 1975)
Water (%)	81,6-83,0	81	/
Protéins (%)	0,8	1,03	2,9
Lipids (%)	0,07	/	/
Carbohydrates (%)	17,0	18-20	/
Calcium (mg)	25,6	30	/
Phosphore (mg)	26,8	10	/
Iron (mg)	0,76-1,8	1,00	/
Fibres (%)	0,60	/	/
Pectins (%)	2,2-3,4	/	/
β-caroten (μg)	21	76,8-81,2	/
Ascorbic acid (mg)	65,8-76,0	73-363	500-881
Thiamin (mg)	0,02-0,024	/	/
Riboflavin (mg)	0,02-0,038	/	/
Niacin (mg)	0,7-0,873	/	/
Vitamin P (Bioflavonoïde)(mg)	/	/	354-1230

Table 4 : Composition (for 100g DM) of *Z. mauritiana* pulp from different areas of northern Cameroon (Biyanzi, 2006)

Components	**Average level**
Proteins (g)	1.2 – 1.3
Lipids (g)	0.6
Total carbohydrates (g)	28.5 – 35.6
Free sugar (g)	14.4 – 18-8
Vitamin C (mg)	81.2 – 92.3
Vitamin A (μg)	20 – 26
Crude fibre (g)	1.4 – 1.9
Total ash (g)	0.8 – 1
- Iron (mg)	1.6 – 2.0
- Calcium (mg)	62.6 – 85.8
- Phosphorus (mg)	59 – 69
Saponins (mg)	0.3
Total polyphenols (g)	0.4 – 0.6
- Tannins (g)	0
- Aglycones (g)	0.06 – 0.2
- Anthocyanins (g)	0.08 – 0.3
Phytates (mg)	0

3.2. Biological properties

Ziziphus fruits have been found to stimulate nitric oxide release *in vitro*, in cultured endothelial cells and *in vivo*, in the kidney tissues of rats (Kim & Han, 1996). A hypothesis was then formulated concerning a possible contribution of *Ziziphus* on the reduction both of blood pressure and inflammation of kidney.

Different triterpenoic acids (colubrinic acid, alphitolic acid, 3-O-cis-p-coumaroylalphitolic acid, 3-O-trans-p-coumaroylalphitolic acid, 3-O-cis-p-coumaroylmaslinic acid, 3-O-trans-p-coumaroylmaslinic acid, oleanolic acid, betulonic acid, oleanonic acid, zizyberenalic acid and betulinic acid) have been isolated from the fruits of *Ziziphus*. Some of them, in particular 3-O-p- coumaroylalphitolic , betulinic acid and oleanolic acid, showed high antitumor, anti-inflammatory and antibacterial properties (Eiznhamer & Xu, 2004; Lee *et al*., 2003, 2004; Kim *et al*., 1998; Hsu *et al*., 1997).

In Cameroon, two pentacyclic triterpens of lupine type (p-coumaryl alphitolic acid) and oleanane type (p-coumaroyl maslinic acid) have been isolated from *Jaabi*, using silica gel 60 chromatography, and have shown good antioxidant activity through *in vitro* inhibition of DPPH (2,2'-diphenyl-1-picrylhydrazyl) radical and decolourisation of the radical cation $ABTS^+$ [2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid)] (Biyanzi *et al*, 2008, 2009). These results suggest that *Jaabi* could be a good source of antioxidants and could potentially be used for the treatment of inflammatory diseases.

3.3. Physico-chemical and sensory characteristics of *Jaabi*

Jaabi is characterized by an intense and pleasant biscuit-like aroma, which may justify the fact that the dry fruit is highly popular as a side dish. This aroma is more developed in the powder and in *Yaabande*, explaining why this local cake is usually considered as biscuit. The cake has a stronger texture than industrial biscuits. The colour of the pulp, powder and *Yaabande* is chocolate like.

4. Consumption forms of *Jaabi*

Dry *Jaabi* fruit is usually consumed as side dish in many cities of northern Cameroon. The main period of consumption during the day is the afternoon. *Yaabande* is eaten as dish, usually at dinner, accompanied by milk into which the cake is crumbled.

5. Research activities and new development on technology and product

The ability of *Ziziphus* tree to grow in a wide range of climatic and agro-ecological zones and the value of the fruit in human nutrition and in medicine has led to its high research interest. This recognition is justified by a huge number of scientific organisations specialised in the study of the tree and its fruits (Azam-Ali *et al.*, 2006). These studies focused mainly on Indian and Chinese varieties of *Ziziphus*.

The crop has been introduced in vast regions of Africa, but although know-how exists on production techniques fruits are still gathered from wild stands,. However, some governments, such as Malian government, have started recognising the interest of *Ziziphus*, through a national programme of incorporation of *Ziziphus* trees into land systems, with the aim of transferring production, management and processing technologies to local farmers, in order to improve both their nutrition status and income, and to develop the processing system of the fruit. The success of such programmes involves additional research studies concerning: market characterisation and development, economic and socio-economic impact on farmer's income, development of management practices which are environmentally friendly, development of post-harvest processing and uses. The post-harvest research needed include: standardisation of harvesting, grading, packaging of fruits, and of processing methods, with regards to cost-effectiveness, marketability and quality of products from fruits.

In addition, since the numerous useful medicinal substances of *Ziziphus* fruit has not elicited interest of pharmaceutical companies for their exploitation, despite the fact that the fruit and the different parts of the tree are regularly exploited by traditional medicine and that numerous substances responsible for these properties have been extracted and scientifically characterised, new research is needed towards provision of cheap and accessible forms of products useful for nutrition and traditional medicine.

Conclusion and perspectives

Taking into consideration the nutrient content of *Jaabi*, its current food use by local populations, its physico-chemical and biological properties, particularly its antioxidant content and its pleasant biscuit-like flavour, the fruit offers interesting hypotheses and research questions for its development for markets.

First of all, the local non-standardised processing practices, raise a question on the effect of these treatments on the quality of the end product, particularly on antioxidant components and properties. This question highlights the interest in studying the local technologies and their relation with the quality of *Yaabande*, regarding the biological properties of the food.

Secondly, considering the richness of *Jaabi* in antioxidant compounds, confirmation of their biological activity through extraction and characterisation appears scientifically interesting, since the extract could be developed and valorised in the treatment of inflammatory diseases. In addition, the formulation of a nutraceutical product based on the use either of the extract or of the whole powder, appears to be an interesting form of valorisation of *Jaabi*.

Thirdly, the aromatic complex of the dry fruit, with regard to its biscuit-like flavour, offers the opportunity to use *Jaabi* fruit or extract as additive in bread-making or as aromatizing ingredient. This valorisation step has to take into account the local practices and uses of the fruits, the behaviour of functional compounds during processing involved in those practices and the formulation of appropriate new products likely to be used as vectors of the developed functionalities.

The implementation of the above research interest of *Jaabi* leans on three main actions:

1. Socio-economic and technological diagnosis of the jujube production and market channels. This action include:
   - Identification and characterisation of production areas and systems
   - Characterisation of the market system
   - Characterisation of local processing practices and uses of the fruits
   - Characterisation of the quality perception and management of the fruits and their products by local actors.
2. Biochemical and physico-chemical characterisation of the fruits, in relation with local practices, with emphasis on:
   - Extraction and characterisation of functional and bioactive compounds
   - Study of the influence of local practices and processing conditions (form of utilisation, temperature, storage conditions, etc.) on the functional properties
3. Formulation of functional and/or composite flours containing *Jaabi* or extracts, and

application in food processing (bread-making, biscuits, flour for gruels, etc.)

References

Ahmedov, V. A. & Halmatov, H. H. 1969**.** Pharmacognostic studies on *Ziziphus jujuba* growing in Uzbekistan [in Russian]. *Rastitel'nye Resursy*, 5: 579-81.

Arbonnier, M. 2002**.** *Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest*. CIRAD, Muséum National d'Histoire Naturelle (MNHN), 2nd ed 573p.

Arndt, S. K. & Kayser, O. 2001. Ziziphus - a medicinal plant genus with tradition and future potential [in German]. *Zeitschrift fur Phytotherapie*, 22:91.

Aubréville, A. 1950. *Flore forestière soudano-guinéenne*, A.O.F- Cameroun-A.E.F. Paris. Société d'édit. Géogr. Marit. Et colon. 523 p.

Azam-Ali, S., Bonkoungou, E., Bowe, C., deKock, C., Godara, A. & Williams, J.T. 2006. *Ber and other jujubes*. J.T. Williams, R.W. Smith, N. Haq, Z. Dunsiger. eds. International Centre for Underutilised Crops, University of Southampton, Southampton, UK. 302 pages.

Baratov, K. B., Shipkova, L. V., Babaev, I. I., & Massover, B. L. 1975. The contents of vitamin C and P and total sugars in some *Ziziphus jujuba* forms cultivated in Tadznik SSR [in Russian]. In *Nauchnye Osnovy Pitaniya Zdorovogo i Bol' nogo cheloveka* T.1. Alma Ata, Kazakh SSR, Kazakhstan 158-160, from Referativnyi Zhurnal 4. 55.810.

Bhansali, A. K. 1975. *Monographic Study of the family Rhamnaceae of India*. Ph.D. thesis, University of Jodhpur, India.

Biyanzi P. 2006. *Caractérisation et étude du dépelliculage sur la qualité nutritionnelle du jujube Camerounais*. M.Sc. thesis, University of Ngaoundéré.

Biyanzi, P., Ndjouenkeu, R., & Mbofung, C. M. F. 2008. *Composition et activité antiradicalaire du fruit du jujubier (Ziziphus mauritiana*, Lam.). CNSS (Cameroon Nutritional Science Society): *Utilisation of natural products for better health*. 12–14 November 2008, Yaoundé, Cameroon.

Biyanzi, P., Ndjouenkeu, R., & Mbofung, C. M. F. 2009. *Caractérisation des antioxydants phénoliques du fruit du jujubier* (*Ziziphus mauritiana*, Lam). Symposium international sur les composés phénoliques: "Nutraceutiques ou médicaments". Agadir (Maroc), 17-18 December 2009.

Chevalier, A. 1947. Les jujubier on Ziziphus de l'ancien monde et l'utilisation de leurs fruits. *Revue Internationale de botanique appliquée et d'agriculture tropicale* (Paris), 27 (301/2): 470-483.

Chivero, E. & Mawadza, C. 1998. *Traditional processing of Ziziphus mauritiana fruits in Zimbabwe*. International Workshop on *Ziziphus mauritiana*, Harare, Zimbabwe, 13-16 July, 1998.

Dalziel, J. M. 1937. *The Useful Plants of West Tropical Africa*. Crown Agents, London, 2nd reprint, 1955.

Eiznhamer D. & Xu Z. 2004. Betulinic acid: a promising anticancer candidate. *IDrugs*. (4): 359-373.

Evreinoff, V. A. 1964. Notes sur le jujubier (*Ziziphus jujuba* Gaertner). *Journal d'agriculture tropicale et de botanique appliqué*, 11: 177-187.

GreatVista Chemicals. 2004. Bioflavonoids (Vitamin P). In, Grewal, S. S., Singh, G. & Dhillon, W. S. (1993) Effect of growth regulators on fruit drop and quality of fruit in ber (*Ziziphus mauritiana* Lamk.). *Punjab Horticultural Journal*, 33(1/4): 76-83.

Hsu, H. Y., Yang, J. J. & Lin, C. C. 1997. Effects of oleanolic acid and ursolic acid on inhibiting tumour growth and enhancing the recovery of hematopoietic system post irradiation in mice. *Cancer Lett.* 111: 7-13.

ICUC. 2002. *Ber, Ziziphus mauritiana* Lam. *Field manual for extension workers*, International Centre for Underutilised Crops, Southampton. 30 p.

Igor de Garine. 2002. *Nourriture de brousse chez les Muzey et les Massa du Nord Cameroun*. CNRS, Paris. 13 p.

Johnston, M. C. 1972. *Rhamnaceae*. In *Flora of Tropical East Africa*, Milne-Redhead, E. & Polhill, R. M. eds. Crown Agents, London.

Kadzere, I. 1998. *Role of Ziziphus mauritiana in the livelihood of some communities in Zimbabwe*. International Workshop on Ziziphus mauritiana, Harare, Zimbabwe, 13-16 July, 1998.

Kalikiti, F. 1998. *Ziziphus mauritiana in Siavonga district, Zambia*. International Workshop on Ziziphus mauritiana, Harare, Zimbabwe, 13-16 July, 1998.

Khurdiya, D. S. & Singh, R. M. 1975. Ber and its products. *Indian Horticulture*, 20:5, 25.

Kim, D. S. H. L., Pezzuto, J. M., Pisha, E. (1998) Synthesis of betulinic acid derivatives with activity against human melanoma. *Bioorganic & Medicinal Chemistry Letters* 8: 1707-1712

Kim, H. Y. & Han, S. W. 1996. *Ziziphus jujuba* and *Codonopsis pilosula* stimulate nitric oxide release in cultured endothelial cells and kidney tissues. *Asia Pacific Journal of Pharmacology*, 11: 26.

Lee, S., Min, B., Lee, C., Kim, K., & Kho, Y. 2003. Cytotoxic triterpenoids from the fruits of *Zizyphus jujuba*. *Planta Med.* 69, 1051-1054.

Lee, S. M., Park, J. G., Lee, Y. H, Lee, C. G., Min, B. S., Kim, J. H., & Lee, H. K. 2004. Anti-complementary Activity of Triterpenoids from Fruits of *Zizyphus jujuba*. *Biol. Pharm. Bull*. 27(11) 1883-1886.

Liu, M. J. & Cheng, C. Y. 1995. A taxonomic study of the genus *Ziziphus*. *Acta Horticulturae*, 390: 161-165.

Maposa, M. & Chisuro, D. 1998. *Importance of Ziziphus mauritiana (masau) in the Mukumbura area of Zimbabwe- From a farmer's and extensionist's point of view*. International Workshop on Ziziphus mauritiana, Harare, Zimbabwe, 13-16 July, 1998.

Morton J. 1987. Indian jujube. In *Fruits of warm climates*. P. 272-275. http://www.hort.purdue.edu/newcrop/morton/indian_jujube.html

Munier, P. 1973. Le jujubier et sa culture. *Fruits*, 28(5): 377-388.

Noyé D. 1989. *Dictionnaire fulfuldé-français. Dialette Peul du Diamaré. Nord-Cameroun*. Paris, P. Genthner / Garoua, procure des missions. 425 p.

Pareek, O.P. 2001. Ber (*Ziziphus mauritiana*, Lam.) Fruits for the Future. A. Hughes, N. Haq & R.W. Smith, eds. ICUC, Southampton, UK. 490 p.

Pareek, O. P. & Vashishtha, B. B. 1983. Delicious ber varieties of Rajasthan. *Indian Horticulture*, 28(2): 13-15.

Penda, S. & Alpha, O. K. 2002. *Etude diagnostique des circuits de commercialisation des produits du jujubier dans la zone sahélienne du Mali : cas de l'arrondissement de Kayes*. 2ème atelier régional sur les aspects socio-économiques de l'agroforesterie au Sahel, Bamako, 4-6 Mars 2002.

Rathore, D. S. 1986. Physico-chemical evaluation of Chinese jujube (*Ziziphus sativa*) fruits. *Progressive Horticulture*, 18(1/2): 65-67.

Seignobos, C. & Olivry, J. C. 2000. *Atlas de la province de l'extrême Nord Cameroun*. MINREST INC Edition IRD Paris. P 38-40.

Troyan, A. V. & Kruglyakov, G. N. 1972. Produce with high vitamin content. *Sadovodstvo*, No. 12: 30.

Vivien, J. & Faure, J. J. 1995. *Fruitiers sauvages d'Afrique - Espèces du Cameroun*. Editions NGUILA-KEROU, France, 416p.

Williams, T. O. 1998. *Multiple uses of common pool resources in semi-arid West Africa: A survey of existing practices and options for sustainable resource management*. http://www.odi.org.uk/nrp/38.html.

Literature review and Background information

of

Kong

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:

AYESSOU, N., KANE, C., KEBE, C.F.,

Ecole supérieure polytechnique de Dakar
Université Cheikh Anta Diop de Dakar

Edited by: Nomusa Dlamini, Joseph Hounhouigan

December 2010

Table of contents

Abstract

The smoked fish called « kong » in Senegal is scientifically attributed to *Arius heudelotii* (Valenciennes, 1840). The smoking occurs all year long and represents 7.5% of traditionally transformed fish in Senegal. This activity is mainly practiced in the regions of Thiès, Ziguinchor, Fatick and Dakar. The type of smoking used is the hot smoking using wood, wood shavings, cardboards and coco stuffing as fuel. The smoking technology is still at traditional level. The final quality depends on water content, which is up to 61%, the amount of B(a)P concentrations varying from 1.81 to 4.15 µg / kg (Rivier et al. 2010). Unfortunately at traditional level technology, the microbiological qualityis unsatisfactory (Adu-Gyamfi 2006; Mugula & Lyimo 1992; Efiuvwevwere & Ajiboye 1996; Oulaï et al. 2007) and presents a serious aflatoxigenic risk (Jonsyn & Lahai 1992; Bukola et al. 2008; Shephard 2003; Uraih & Ogbadu 1981). In another study, Goueu (2006) found that 96.76% of the results were satisfactory. Nevertheless, the exportations to Europe has decreased since 2005 and was stopped in Senegal. Many studies have been made in order to improve the smoking process and the fish quality. New smoking processes have been developed to get a lower level of benzo[a]pyrene content (Rivier et al. 2010; Stołyhwo 2005 and Knockaert 1995) such us the choice of wood (Stumpe-Vıksna et al. 2008; Nakajima et al. 2007). For the microbiological quality, chemical preservatives are used (Diop et al. 2010; da Silva et al. 2008; Tiamiyu et al. 2005). Some studies investigated the improvement of storage life using sliced, vacuum-packed product for a better shelf-life (Vergara et al. 2001; Civera et al. 1995).

Introduction

The practice of smoking Kong in Senegal is very old. The aim is to produce a new product rather than a means of preserving surplus fish. From this point of view, the consumer gives the smoked Kong qualities peculiar to it. This is a popular food whose selling price in the markets is relatively high for the average Senegalese. The technology used is that found in tropical countries. This is a hot smoking process marked by baking and dehydration accompanied by an infiltration by smoke. In Senegal, this smoking technique remains today at traditional level despite some efforts to modernize the production facilities. This literature review covers all aspects of the smoked Kong chain including major production areas, the availability of the resource, quality aspects in terms of food safety (biochemical and microbiological), storage, marketing and economic data. The opportunities offered by the research findings will be explored to consider improving the quality of the finished product. These arrangements should ensure compliance of smoked Kong for European requirements, better stability, and bring about new opportunities for exports.

1. **Traditional processing of the product**

1.1.Presentation of the raw material

The smoked fish called « kong » in Senegal is scientifically attributed to *Arius heudelotii* (Valenciennes, 1840). It belongs to the Family of Ariidae such as « catfish ». Its length and weight can vary respectively from 30 to 60 cm and its weight ranges from 400g to more than 1200g. *A. heudelotti* is a fish which can be found in the West African coast located from Senegal to Angola. Other similar fishes which belong to the same family are found in other African countries. These varieties are called: *A. luniscutis* (Guyane), *A. albicans* Guyane*)*, *A. parkii* (Guinée), *A. latisculatis (*Gambie, Gabon), *Chrysichthys spp (Côte d'Ivoire)*, *Clarias gariepinus*, *Ictalurus furcatus*. The main important property is that all catfish is smoked.

Figure 1: A specimen of *Arius heudelotii* (Valenciennes, 1840)

1.2.The smoking of kong

In Senegal, the type of smoking used for the Kong is specially the hot smoking (cooking+drying with the smoke and/or the natural drying with the sun). This is done with the improved traditional smoking devices (chorkor, parpaing, Côte d'ivoire) and so other devices

Traditional oven made with ferro-concrete	Traditional oven made with recycled barrels

Figure 2: typical ovens in traditional fish smoking

Wood, wood shavings, cardboards and coco stuffing are usually used as fuel. The smoking process lasts for 16 to 24 hours. During this time, some interruptions are observed in order to turn the fish in the oven. The temperature at the heart of the fish, during the smoking, can reach 100°C but rarely exceeds 140°C. The loss in weight of the fish is about 55%. The different steps of the smoking process are summarized in the following diagram:

Figure 3: The smoking process of kong

In general, the combination of drying and smoking is the most common technique that is used in West Africa (Gret, 1993). The nature and the availability of the fuel, depending on the region, can cause some differences: wood, wood shavings, cardboards and coco stuffing, cow-dung (Keita, 2005) and even fish scales. However, in some cases, one short step of salting in terms of time, can be performed before the smoking. In Senegal, a similar product is produced by heat treatment. Its name is *Ketiakh*. In fact, it's a braised sardine and then dried naturally under the sun. During the drying process, the sardine is highly salted.

Ketiakh production represents 55% of the national halieutic products transformed while the smoked fish produced under heat conditions, also called *métoroh*, represents 10% of the production in 1995 (Ndoye, Moity-Maïzi & Broutin 2002). These percentages were respectively 46% for the first one and 7.5% for the metorah in 2008 (DPM, 2009). By taking into account the *kong* and *kethiah* way of consumption (Table I), the smoking technique in heat conditions is needed because the fish must be cooked entirely or half cooked.

Tableau I : Main type of fish ??? products obtained by heat treatment process in Senegal

Products	Species	Treatment method	Type of consumption
Smoked, dried fish Kong included	*Metora* (big fishes such as opened kong, entire small) Small pelagic, skate and shark	Heated smoking (cooking) followed by drying with smoke and/or with the sun	Substitut de poisson frais ou condiment
Braised, salted, dried	*Ketiakh* small pelagic (sardine)	Braised, dressed, salted and dried	Substitute of fresh fish or Condiment

Source: Ndoye et al. 2002

The smoked kong is wrapped up in papers and then packed in baskets for transportation. For local consumption, especially in urban markets, the smoked kong is stocked under ice in old fridges which are out of use. The stocking time never exceeds five days because of the kong high water content. Contrary, the smoked kong destined for exportation, is highly dehydrated and stocked at 25°C during about 4 weeks. However, the hydrometric conditions may cause some infestations due to insects or moisture.

2. The Fishing of *A. heudelotii* : Socio-economic importance

2.1. Statistics data

The results of maritime fishing in 2008, show a small increase in kong capturing, increasing from 421 910 tons in 2007 to 426 528 tons in 2008. The kong is essentially fished in artisanal way which represents 90% of the total capturing and 6512787 fisher-man are involved. This activity had contributed, in 2008 to 10.62% of the primary sector added value and 1.35% of the Gross Domestic Product (GDP).

The quantity of fresh Kong fish per year, during the last three years (2006 to 2008) is about 12500 tons, which represents 4% of the fishi in Senegal (DPM, 2007, 2008, 2009). Let us remind ourselves that 94.6% of the Kong is fished using the artisanal fishing way and all of the capturing (100%) is smoked. In fact, there is no data on the exact percentage which is smoked. But, it is well known that cooking fresh Kong is not in culinary practice in Senegal. The repartition booked by the statistics (Table II) shows that the main regions of kong fishing are Thiès, Ziguinchor and Fatick.

Table II: Landing distribution of artisanal Kong's fishing in Senegal

Regions		Tons (2006)	Tons (2007)	Tons (2008)
Dakar	Artisanal fishing	120.34	57.84	92
Thiès		7526.11	5615.10	5021
Saint-Louis		272.35	319.23	239
Ziguinchor		3535.25	4745.62	3740
Fatick		787.92	533.32	1030
Louga		24551	72.45	85
Kaolack		0	72.45	0
Overall artisanal fishing		12497.48	11418	10207
Industrial fishing		714.87	1867.69	1562.80
Total		13212.35	13285.69	11769.80

(Sources: DPM, 2007, 2008, 2009)

According to the statistics, our sites of investigations during this program are showed on the following map (Figure 4): it seems easy to identify two groups:

* The first one gathered Ziguinchor, Karabane, Cap-skiring and Kafountine. All those sites are localized in the deep south of Senegal, where the climate is a soudanian one.

*The second group is localized in the south of Dakar, called the little coast (Dakar, Joal, Djifère) in addition to Loumpoul, and Saint-Louis in the North (the big coast). The climate in these group regions is a sahelio-soudanian one.

This classification is important. Indeed, it will influence the raw material quality and define the type of fuel (combustible) available to be used to make the smoke.

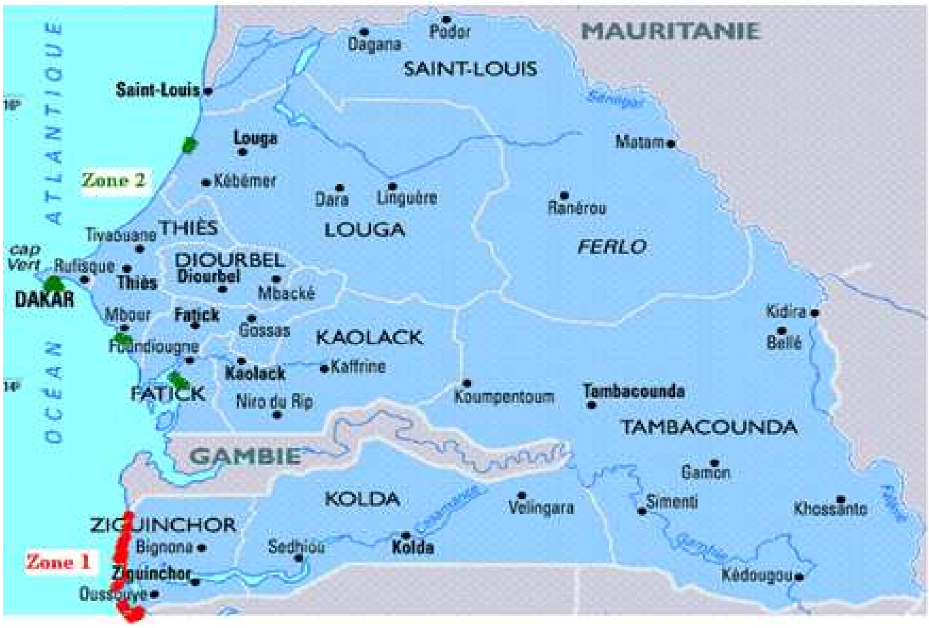


Figure 4: The map of important fishing's sites of *Arius heudelotii* in the Senegal

Zone 1: Karabane, Cap-skiring, ziguinchor, kafountine ; Zone 2: Dakar, Joal, Djifère (Fatick), Loumpoul (Louga) and Saint-Louis

2.2. Availability of the raw material (Sources: DPM, 2007, 2008, 2009)

Monthly distribution of the fishing shows that the smoking activities of kong occur all along the year in Senegal. No seasonal variability is noticed (Table III).

Table III: Monthly landing's distribution of Kong (tons)

	January	February	March	April	May	June
2006	681.86	806.11	1201.32	1252.77	1198.10	1101.53
2007	768.29	730.53	741.35	868.27	837.81	907.08
2008	397.75	762.29	714.96	734.32	1054.59	899.99
	July	August	September	October	November	December
2006	1016.15	921.11	793.29	922.62	1304.62	1388.01
2007	1293.95	1051.64	1083.91	888.78	1083.85	1088.11
2008	791.96	659.49	960.67	907.93	1415.96	907.30

2.3. Statistic and economic data on smoked fish

According to the statistical data, smoked kong is booked as "metora" including those little fishes which are also smoked and even the "kétiakh". Then, it is easy to globalize and summarize the production of smoked kong during the last three years in Table III.

Table III: Fresh and smoked kong production in Senegal

Years		2005	2006	2007	2008
Fresh Kong (tons)		21952.45	13212.35	13285.69	11769.80
Smoked kong	tons	2182.95	1220.13	2032.31	3534.1
	Percentage	9.94%	9.2%	15%	30%

The price of smoked fish varies between 2.3 euros and 5 euros but may reach some times 6 euros. Most of the time, the sale in Dakar's market is a business lead to Guineans. On the exportation of smoked fish, we notice that during the year of 2005, 33.85 tons were exported to Europe representing about 48.3 millions Euros. This quantity decreases to 1.5 tons and represents 5201 Euros in 2006. Then, since 2006, any quantity is exported to Europe. Nevertheless, in Africa, the exportation is quite constant (Table IV).

Table IV: Exportation of smoked fish from Senegal from 2005 to 2008

Destination	Europe 2005	Europe 2006	Europe 2007 -2008		Africa 2005	Africa 2006	Africa 2007	Africa 2008
Tons	21.51	1.46	0	0	678.35	416.06	494.76	366.17

VCE (x 1000 CFA)	19 647.8	3417.22	0	0	439 577.28	269603.64	321594	238010.5

(Sources: DPM, 2007, 2008, 2009)

According to Ward (2003), the quantity of smoked fish from West Africa entering the United Kingdom is estimated to be about 500 tons per year with a retail value of £5.8 to £9.35 million.

Nigeria currently exports approximately 60 tons of smoked fish per year. The other major exporting countries are Ghana, Ivory Coast and Cameroon. Unfortunately, 20 tons of product with a retail value of £240 000 to £390 000 are destroyed.

With the exception of biochemical and microbiological quality, the main problems associated with exportations of smoked kong or fish are:

Inadequate packaging

Insect infestation

Mould development

Bad practices in processing of necessary paperwork for export/import.

3. The smoked Kong's characteristics

3.1. Biochemistry and sensorial quality

The common quality criteria for the consumers and the producers of smoked Kong are: for the color (orange to dark brown); water content (34 to 40%). However, recent works on the smoked Kong characteristics in Dakar markets revealed that there is 61% water content, and the amount of phenols is 18 to 95mg per 100g of dried fish and the B(a)P concentrations vary from 1.81 à 4.15 µg / kg (Rivier, Kébé, Sambou, Ayessou, Azoumah & Goli 2010). In addition, these studies revealed that by using wood shavings. there is less B(a)P, but more phenols and better sensorial results. On the other hand, less overall phenol and B(a)P contents are observed when the couple charcoal+wood shavings are used as fuel (Rivier et al. 2010).

A new smoking theory has been developed (Maherzi 2009; Rivier et al. 2010) and is based on:

The separation between the smoking and the drying;

The use of wood shavings and charcoal; :

The successive use of smoking followed by drying sequences.

3.2. Nutritional quality

The nutritional quality of smoked fish is quite different to that of fresh fish in general. The smoking process does not produce big changes in kong quality. The composition of a new fresh fish such as *Arius* species, specially A. *caelatus* is as follows according to Azam, Ali, Asaduzzaman, Basher & Hossain (2004): 19.06% protein; 6.79% lipid ; 25.75% TVBN. An extended analysis on smoked *A. heudelotii* (Laure 1974) give the following nutritional composition.

Table V: Nutritional facts of smoked kong (Laure 1974)

	Moisture (%)	Protein (%)*	Lipid (%)*	Mineral matter (%)*	Calorific value Kcal/100g*	Ca mg/100*	P mg/100*	Fe mg/100g *
Average	23.7	72.6	11.7	22.7	317- 416	7050	3750	24.8

* Dehydrated product

Recent studies on smoked kong gave the following results:

Moisturs: 56%; Protein: 43.13% (Rivier et al., 2010)

lipids: 9.10% ; Total volatile nitrogen (TVN): 16mg/100g (Rivier et al. 2010)

Phenol: 18 to 92mg/100g (Rivier et al. 2010)

Benzo(a) Pyren like (main Polycyclic aromatic hydrocarbons) HAP: < 4,5mg/kg (Rivier et al., 2010)

The kong is a low fatty fish having less than 10% of lipid content. According to Laure (1974), the fat of the fish is essentially composed by unsaturated fatty acids (65 to 75%).

These fish lipids contribute in reducing cardio-vascular illnesses. Two fatty acids with very long chemical chain play an important role in that. Their names are eicosapentaenoïc acid (EPA) and docosahexaenoïc (DHA). Cholesterol content is lower in flesh fish when compared in meat: 20 to 70 mg in 100 g of the comestible part of the fish. One of the advantages of consuming fish is that it provided the body with iodine, vitamins such as vitamin B6, B12 and biotin. Furthermore, fatty flesh fish is particulary rich in vitamin D.

3.3. Microbiological quality

There is no available data on microbiological quality of smoked kong in Senegal. Due to the lack of national standards, the French microbiological standards can be applied (France, 1980).

Mesophilic aerobic bacteria : $<10^6$/g

Faecal coliforms: Absence/g

Staphylococcus aureus: 1/g

ASR at 45°C : Absence/g

Salmonella sp: Absence/25g

This standard is more constraining but it can be followed by the producers. Initial studies on smoked fish from Ivory Coast showed that 69.3% of the analyzed samples were not safe for consumption (Oulaï, Koffi, Koussemon, Djé, Kakou & Kamenan 2007). However,, ten years later, with some technical support programs of the sector, other studies done on 1819 samples of smoked fish during the period of 2002 to 2006 showed that 96.76% of the results were satisfactory (Goueu 2006).

4. Consumption forms of smoked kong

4.1. Food forms

Smoked kong is consumed in two ways

*cooked : Soups called:

“sauces graines” (Ivory coast, Bénin, Togo…)

“sauce gombo” (soupe kandja in Senegal)

“Bouillon de machoiron” + bananas or cassava

*not cooked: “moyo ou ébesséssi” + akpan, pâtes, foufou

4.2. Period of the day for consumption (breakfast, lunch, dinner)

The smoked kong is eaten at lunch or dinner

5. Some recent researches about smoked fis*h*

The smoked fish quality depends on the technology used for making it (smoking room, fuel). Comparative studies on the cost, the profitability and the quality of the smoked fish classify the traditional oven according to this order: smoking room chorkor, smoking room Dafing and smoking room Monoclais (Kabré, Diarra & Traoré 2003). But some experiments performed in some smoking room supplied with external steam generator reduce benzo[a]pyrene from 50 to 0.1 µg /kg wet weight (Stołyhwo 2005). By using modern technologies such as electrostatic smoking, better results can be obtained, especially on the process cost, product quality, safety and environment (Knockaert 1995).

By improving the quality, it was found that the type of wood has a significant influence on the amount of polycyclic aromatic hydrocarbon (PAH) in smoked meat (Stumpe-Vıksna, Bartkevic, Kukare, & Morozovs 2008). For example, Nakajima, Nagame, Kuramochi, Sugita, Kageyama, Shiozaki, Takemura, Shiraishi, & Goto (2007) then Stumpe-Vıksna et al. (2008) showed that samples smoked with apple-tree and alder contained the lowest PAH concentrations. Those samples smoked with spruce had the highest concentrations of PAH. The difference in content of benzo[a]pyrene (from 6.04 till 35.07 µg/kg) and total PAH (from 47.94 till 470.91 µg/kg) indicates that choice of wood for smoking is one of the critical parameter to be controlled in order to reducethe contamination of food products. The smoking process also influence biochemical components such us phenolic compounds (Sérot, Baron, Knockaert & Vallet 2004) and PAH (Nakajima et al. 2007).

Unfortunately at the traditional level of technology, the microbiological quality is unsatisfactory. Investigations on smoked fish from retail market show the presence of total aerobic bacteria, faecal coliforms, *Escherichia coli*, *faecal streptococci*, *Staphylococcus aureus*, *Lactobacillus* and moulds *(*Adu-Gyamfi 2006; Mugula & Lyimo 1992; Efiuvwevwere & Ajiboye 1996; Oulaï et al. 2007). Moreover, in smoked dried fishes stored for sale, conditions are usually favorable for the development of the mould and the risk of producing toxins such as aflatoxin. In some cases, moulds like *Aspergillus flavus* were found, and these are aflatoxigenic, (Mugula & Lyimo 1992; Jonsyn & Lahai 1992). This is confirmed by several studies (Jonsyn & Lahai 1992; Bukola, Abiodun and Ukpe 2008; Shephard 2003; Uraih and Ogbadu 1981). During storage also, insect infestation by *Dermestes spp*. and mites was observed (Mugula & Lyimo 1992).

All these surveys emphasize the importance of proper processing and handling of fish in order to safeguard public health. Usually, chemical preservatives are used for microbial stability. Efiuvwevwere & Ajiboye (1996) propose sodium benzoate or potassium sorbate. Frankard, Jacob and Lambert (1990) and Sofos (1984) propose only sodium chloride and other ion chloride salts; **da Silva, Prinyawiwatkul, King, No, Bankston Jr. & Ge** (2008) propose NaCl with ascorbic acid or sodium lactate with or without 5% rosemary extract. Tiamiyu, Ogbe, and Okpale (2005) propose spice extract juices (ginger and garlic juice extract). Diop, Destain, Tine and Thonart (2010) propose the use of lactic bacterium and the bacteriocin. For aflatoxin inhibition, **Ogbadu (**1988) propose gamma irradiation to prevent aflatoxin B_1

production in smoked dried fish. For all those chemical preservatives, maximum shelf-life is about 6 to 8 weeks at no refrigerated storage. This seems to be better than sliced vacuum-packed product for which Civera, Parisi, Amerio & Giaccone (1995) forecast a lengthening of shelf-life to 11 weeks at refrigeration temperature. Some authors forecast 4 weeks (Vergara, Di Pinto, Losito & Tantillo, 2001) and others 3 or 6 months for sliced vacuum-packed product kept at refrigeration temperature.

If applied, these new innovations will, for sure, increase kong fishing and smoked kong exportation. Unfortunately, the maximum sustainable yield has been reached and the kong is already supposed to be over exploited (Samba, Mbaye, Dème, Thiam, Sarré, Fall, Barry, Ngom & Diouf 2007; Fall 2009). This trend was predictable because Gascuel & Ménard (1997) had drawn up already a list before 1981 showing that 11 species of fish were over exploited in Senegal. The situation is very critical for *Arius* sp (Gascuel & Ménard 1997). Moreover, their results can be interpreted as a sign of fragility of the ecosystem.

Conclusion

The state-of-the-art on the smoking of the kong shows that new alternative pathways of the traditional smoking can be performed in order to satisfy the new quality constraints of food processing. However, these new technologies need to take into account local context or realities such as the scarcity of wood, the availability of construction materials and consequently the smoking process.

Recent research results on smoked fish stability will be applied in our studies, for example, as the use of lactic bacterium and the bacteriocin, salt. The application of combined new processes in order to stop bacteria and mould development, so as to limit aflatoxin levels, TVN, histamine and PAH's production will be attempted. Moreover, packing under vacuum of the product and the storage condition at 4°C will increase the use-by date according to Civera et al. (1995) and Vergara et al. (2001). But the resource is already supposed to be over exploited that is why for a viable and durable development of the "smoked kong" production, more studies are needed in order to diversify the source of the resource supply. For example, the ecosystem and kong's stock reconstruction can be made or explored. The development of fish breeding should be practiced too.

References

Laure, J. 1974. Valeur nutritionnelle des produits de la pêche conservés artisanalement au Cameroun et au Tchad. ORTSOM ed., Paris France, 81p.

Rivier, M., Kébé, F., Sambou, V., Ayessou, N., Azoumah, Y. & Goli, T. 2010. Fumage de poissons en Afrique de l'Ouest pour les marchés locaux et internationaux. Rapport d'activités de recherches financées par l'AUF. 59p

Fall, M. 2009. Pêcherie démersale côtière au Sénégal – Essai de modélisation de la dynamique de l'exploitation des stocks. Thèse Univ. Montpellier 2, 231p.

Ndoye, F., Moity-Maïzi, P., Broutin, C. 2002. Le poisson fumé sur la Petite Côte Sénégalaise. Ed. ENDA-GRAF, Montpellier France, 88p.

Stumpe-Viksna, I., Bartkevic, V., Kukare, A. & Morozovs A. 2008. Polycyclic aromatic hydrocarbons in meat smoked with different types of wood. *Food Chemistry* 110, 794–797.

Uraih, N. and Ogbadu, L. 1982. Influence of woodsmoke on aflatoxin production by *Aspergillus flavus*. *Rev. Applied Microbiology and Biotechnology* 14 (1), 51-53.

Goli, T. 2006. Contrôle de la teneur en hap dans les poissons fumés en côte d'ivoire, rapport d'expertise, Abidjan, 20p.

Maherzi, M. L. 2009. Etude et amélioration de la fabrication traditionnelle de poisson fumé au Senegal, Montpellier supagro, 77p.

Gret 1993. Groupe de Recherche et d'échange technologique. *Conserver et transformer le poisson.* Collection le point sur. Saint-Étienne, 286 p.

Goueu, B. B. 2006. Contribution à l'étude de l'évolution de la qualité microbiologique du poisson fumé en Côte d'ivoire et destiné à l'exportation. Thèse de Médecine vétérinaire, univ. de Dakar 175p.

Oulaï, S. F., Koffi, R. A., Koussemon, M., Djé, M., Kakou, C. Kamenan, A. 2007. Evaluation de la qualité microbiologique des poissons Ethmalosa fimbriata et Sardinella aurita fumés traditionnellement 2007, MHA 19 (55) 37-42.

Azam, K.M.Y., Ali, M.Y., Asaduzzaman, M., Basher, M.Z. & Hossain, M.M. 2004. Biochemical assessment of selected fresh fish. *Journ. Biological Sciences* 4 (1), 9-10.

Kabré, A.T., Diarra, D., Traoré, A. 2003. Le fumage du poisson au Burkina Faso : comparaison des caractéristiques et de la rentabilité de trois types de fumoirs améliorés. Cahiers Agricultures. Volume 12, Numéro 6, 409-17, Novembre-Décembre 2003

Direction des pêches Maritimes DPM. 2007. Résultats généraux des pêches maritimes 2005, 110p.

Direction des pêches Maritimes DPM. 2007. Résultats généraux des pêches maritimes 2006, 108p.

Direction des pêches Maritimes DPM. 2008. Résultats généraux des pêches maritimes 2007, 114p.

Direction des pêches Maritimes DPM. 2009. Résultats généraux des pêches maritimes 2008. 111p.

Ndoye, F., Moity-Maïzi, P. Broutin, C. 2002. Le poisson fumé sur la Petite Côte sénégalaise, Ed. CIRAD, Montpellier France, 90p.

République de France 1980. Arrêté de la république française du 21 décembre 1979 relatif aux critères microbiologiques auxquels doivent satisfaire certaines denrées alimentaires d'origine animale. Journal officiel de la république française (JORF). Paris. 10 janvier.

Knockaert, C. 1995. Fumage électrostatique : Application aux produits de la mer. Document IFREMER, 110p.

Sérot, T., Baron, R., Knockaert, C. and Vallet, J.L. 2004. Effect of smoking processes on the contents of 10 major phenolic compounds in smoked fillets of herring (Cuplea harengus). *Food Chemistry* 85, 111–120.,

Stołyhwo, A. and Sikorski, Z.E. 2005. Polycyclic aromatic hydrocarbons in smoked fish: a critical review. *Food Chemistry* 91, 303–311.

Nakajima, D., Nagame, S., Kuramochi, H., Sugita, K., Kageyama, S., Shiozaki, T., Takemura, T. Shiraishi, F. & Goto, S. 2007. Polycyclic Aromatic Hydrocarbon Generation Behavior in the Process of Carbonization of Wood. *Bull. Environ Contam. Toxicol*.79, 221–225

Diop, M. B., Destain, J., Tine, E. and Thonart, P. 2010. Les produits de la mer au Sénégal et le potentiel des bactéries lactiques et des bactériocines pour la conservation. *Biotechnol. Agron. Soc. Environ.* 14 (2), 341-350.

Civera, T., Parisi, E., Amerio, G. P. and Giaccone, V. 1995. Shelf-life of vacuum-packed smoked salmon: microbiological and chemical changes during storage. *Archiv für Lebensmittelhygiene*, 46 (1), 13-17.

Vergara, A., Di Pinto, A., Losito, P. and Tantillo, G. 2001. Microbiological and chemical quality of vacuum-packed smoked salmon up to the declared expiry date. *Advances in food sciences* 23 (1), 25-30.

Ward, A. 2003. A study of the trade in smoked-dried fish from West Africa to the United Kingdom. *FAO Fisheries Circular* 981, 17p.

Gascuel, D. & Ménard, F. 1997. Assessment of a multispecies fishery in Senegal, using production models and diversity indices. *Aquat. Living Resour.* 10, 281-288.

Keita, D.M.O. 2005. Contribution à l'étude de la qualité des poissons transformés (fumés, séchés) à Bamako, Mopti, Niono et Sélingué. Thèse de Médecine, Univ. De Bamako, 139p.

Samb, B., Mbaye, A., Dème, M., Thiam N., Sarré A., Fall M., Barry M., Ngom F. and Diouf

K., 2007. Impacts de la législation sur la ressource et les systèmes pêche. Ministère de

l'Agriculture et de la sécurité alimentaire, CRODT/ISRA: juin 2007, 37p.

Bukola, C. A-T., Abiodun, A. O. and Ukpe G. P. 2008. Mycofloral of Smoke-Dried Fishes Sold in Uyo, Eastern Nigeria. *World Journal of Agricultural Sciences* 4 (3) 346-350.

Shephard, G. S. 2003. Aflatoxin and Food Safety: Recent African Perspectives. *Toxin Reviews* 22 (2-3) 267-286.

Mugula, J. K. & Lyimo, M. H. 1992. Microbiological quality of traditional market cured fish in Tanzania. *Journal of Food Safety* 13 (1) 33–41.

Efiuvwevwere, B.J.O. & Ajiboye, M. O. 1996. Microbiological quality and shelf-life of catfish *(Clarias gariepinus)* by chemical preservatives and smoking. *Journal of Applied Microbiology* 80 (5) 465–470

Jonsyn, F. E. & Lahai, G. P. 1992. Mycotoxic flora and mycotoxins in smoke-dried fish from Sierra Leone. *Nahrung* 36(5) 485-489.

Adu-Gyamfi, A. 2006. Studies on microbiological quality of smoked fish in some markets in Accra. *Ghana J. Sci.* 46 67-75.

Da Silva, L. V. A., Prinyawiwatkul, W., King, J. M., No, H. K., Bankston Jr, J. D. and Ge, B. 2008. Effect of preservatives on microbial safety and quality of smoked blue catfish (*Ictalurus furcatus*) steaks during room-temperature storage. *Food Microbiology* 25 (8) 958-963

Tiamiyu, L.O., Ogbe, F.G. and Okpale, E.O. 2005. *Effect of locally available spices on the organoleptic and storage periods of Heterotis niloticus.* In: 19th Annual Conference of the Fisheries Society of Nigeria (FISON), 29 Nov - 03 Dec 2004 , Ilorin, Nigeria.

Frankard, B., Jacob, C. and Lambert, J. 1990. Conservation de la truite Arc-en-ciel: aspects microbiologiques et chimiques. I: Mise au point d'une méthode de salage et de fumage. *Belgian journal of food chemistry and biotechnology* 45 (4) 123-128.

Saidou, M., Diop, J.P., Haoua, S.S. & Mamane, A. (2008). «Expérimentation conjointe de l'innovation paysanne en fumage de poissons en banda au Niger», prolinnova, (site consulté le 6 mars 2009), <*www.prolinnova.net/working_papers/working/fish/smoking*

Salaudeen, M.M., Akande, G.R., Oguntade, O.R., Afolabi, O.O., Olusola, A.O. & Ezekiel, M.O. 2010. Effet des conservateurs sur la sécurité microbiologique et la qualité du poisson-chat fumé *(Clarias gariepinus*). Acta SATECH 3(2) 81 – 86.

Schesnes, M. 2009. Préparation à la mise en place d'un projet MPD pour l'amélioration de fumoirs à poissons. AgroParis-Tech ENGREF, Montpellier, Mémoire d'ingénieur, 86p.

Literature review and Background information

of

Baobab fruit pulp

Part of the deliverable D1.1.1.2 (Workpackage 1)

Authors:

Cisse, M., Ndiaye, C.

Ecole supérieure polytechnique de Dakar
Université Cheikh Anta Diop de Dakar

Edited by: Annali Jacobs, Joseph D. Hounhouigan

December 2010

Table of contents

Abstract

Introduction: **The** Baobab tree has an Arabic history, and belongs to the Bombacaceae family and Adansonia gender. There are eight species in the world including *Adansonia digitata L*. which is found in Senegal. This species is encountered in many African zones and has a long life. The baobab is used for many purposes and represents an important source of income for the Senegalese people when solely valorized in traditional ways. The flowering of the plant begins in June and ends in January when the fruit is fully ripened in its capsule. The fruit can be harvested all year round. The most common name of baobab fruit pulp in Senegal is “Monkey bread” or "Bouy".The baobab pulp is economically the most important food stuff, and is recognized by the EU commission as an additive and exported in many countries. Traditional processing of the product: The growth of small and middle enterprises makes this fruit important. Although it is still traditionally processed, the baobab fruit pulp has covered many different applications ranging from primary products to increased in value products. The description and similarity/variability of processing methods depend on the markets’ destination. The major problems associated with the processing of baobab pulp are linked to vitamin C loss. An understanding of the various processing parameters is necessary to produce good quality products. The nectar’s stabilization need to be improved as well as the dried pulp for its exportation. The organoleptic quality attributes during storage need to be kept at high level by processing technologies to ensure safety and attractiveness of the final products.

Socio-economic importance: Baobab plants are found in many parts of Senegal with two main production area Kaoalack and Tambacounda. According to the Senegalese Institute of Agricultural Research: the Baobab Fruit Company Senegal, a supplier to a family firm Baobab Fruit Company from Italy for exportation purpose, while the remaining sectors are in the small and medium scale enterprises as well as households and culinary users. Depending on the target markets, the harvested fruit products are well represented in trade and consumption. The different ways of using baobab fruit pulp introduce a good source of income for the local population. The market price of the baobab fruit pulp depends on seasonal availability. With substantial income for somecompanies, there is a growing interest for this product indicating future development toward Europe and other continents.

Quality characteristics of the product: The quality aspects of baobab products depend on intrinsic and extrinsic parameters governing the food products. The important parameters include the nutritional and microbiologicalqualities. Furthermore, pectin and other

components play important role in the quality of the baobab by products. Some baobab pulp components meet the recommended daily intake (RDI) of nutrients in different population levels. Also, due to many beneficial health effects and food technological functions, baobab fruit pulp is a very interesting candidate for a new generation of functional foods and drinks. The stable microbiological status as well as theprebiotic effects of baobab pulp have been mentioned by many authors. The physico-chemical characteristics of baobab pulp show many trends making this fruit more interesting compared to some other fruits. The sensory characteristics of the pulp and by products especially the appearance, the color, the taste and the flavor are affected during processing and storage, and thus it is important to overcome these difficulties. The quality perception/requirement by consumers depends on the kind of by products from the baobab fruit mixed with or without other foods. Some recent studies showed the important antioxidant activity of the complete plant (pulp, leave, fibers), which lead to many potential applications actually and may need more research to fulfill the traditional assumption made before.

Consumption forms of the product: There exist various food forms of baobab pulp with traditional processing status. The period of day consumption depend on the special events and the type of food, from breakfast to dinner.

Research activities and new development on technology and product: The pulp and nectar of baobab fruit pulp, assumed as natural and functional food category, need more research to improve stability, storage conditions as well as the functional properties of the by products. The increasing consumer interest in ethnic and traditionally processed products makes baobab a good candidate for research. The traditional processing of baobab fruit needs to be evaluated and improved technologies be adapted. Furthermore, a good opportunity will be the comparison studies between *Adansonia za* (most used species in Madagascar) with *Adansonia digitata L.* (only species from Senegal) for many reasons. Furthermore, to my knowledge no data is available on *A. za* including the physico-chemical and biochemical composition and processing technology of any products from this species. An open way for results to be exploited will be a concern.

Conclusion: The perspectives on research and innovations can be divided into different ways including: more appropriated extraction methods of baobab pulp; the possible increase in value of bioactive components by improved processing technology, in this way the use of microencapsulation of some specific healthy bioactive components can be investigated as well as soluble and insoluble dietary fibers. There is also need for research that will focus on the thermal stabilization of locally produced baobab fruit pulp nectar as well as on vitamin C conservation using kinetic factors other than water activity. Another route would be to use enzymes to increase the yield of the baobab fruit pulp juice and syrup yield, as well as increasing its stability and organoleptic properties (functional food components). A study on the pulp concentration aroma lost and ultra high temperature (UHT) pasteurization may also be explored, as well as the evaluation of the effect of browning reaction on organoleptic quality, as well as other undesirable changes of final products. The benefit of some microbiological properties particularly found in dietary fibers of the baobab fruit pulp needs to be kept during the process. The optimization of the processing parameters will help a lot.

Introduction

From its English common name baobab by translation, the fruit is probably derived from the Arabic bu hibab, which means “fruit with several seeds» (*1, 2*). The baobab, from its descriptor Michel Adanson, belongs to Bombacaceae family in which the gender is Adansonia. Also it originated from tropical Africa (*1*, *3*). There exist eight species of baobab in the world including *Adansonia digitata L.* mostly found in Africa and which was botanically named by the French Carl von Linné and Bernard de Jussieu (*1, 3, 4*). The baobab (*Adansonia digitata L.*) is important to the livelihood and can be found in most of Sub-Sahara Africa’s semi-arid and sub-humid regions as well as in western Madagascar providing food, medicine, etc. (*5-7*). African baobab is a very long-living tree. It normally lives for about 500 years, but it is believed that some trees are up to 5000 years old (*2*). It has been introduced to areas outside Africa and grown successfully (*8*). In many part of Africa tubers, fruits, seeds, leaves and flowers of this plant are identified as common ingredients in traditional dishes in rural and urban areas. Also, baobab is an important source of income for Senegalese people and solely valorized in traditional way (*5*).

In Senegal, the flowering begins at June. The leaves come up with flowers at the same time and persist till October. Between August and October, the fruits form and grow before reaching the final size. As this time, the capsule is green and humid. From November to January, the fruit dry on the tree. When the capsule goes dark, the fruit is ready for harvesting. The harvesting time is mainly between January to February, but can be continued the all year because the fruit is well conserved on the tree for long months (*9, 10*)

Monkey bread or baobab, is generally assumed to be derived from the fact that monkeys eat the baobab’s fruit (*6*). This fruit is a poly sperm berry, ovoid, with ligneous epicarp. The numerous linked seeds coated with whitish pulp are generally dried (*10*). Baobab fruit pulp is called "Bouy" or Monkey bread is widely used by Senegalese people and it is consumed in different forms (*5*).

The pulp is probably the most important foodstuff in baobab fruit because of the strongest economic potential as compared to the remaining parts (*1, 7, 8, 11*). The same pulp was approved by the European Commission as a convenient additive (Phytotrade Africa 2008). The exportation of the dried pulp from Sudan to England allowed to pharmaceutical industries to produce inflammatory products. From Senegal also, the fruit is exported towards some European countries. In fact, the ingredients in powder form are well used in many circumstances for conservation advantages (*12*).

1. Traditional processing of the product

In Senegal, traditional processing of the baobab pulp have improved a lot by the creation of many growing small and medium scale enterprises.

1.1.Raw materials and additives used and their handling

The ripe baobab fruit pulp appears as naturally dehydrated, powdery, whitish colored and with a slightly acidulous taste, and its separation from the shell only needs single mechanical process without any extraction, concentration or chemical treatment (*13*). This ensures that the pulp characteristic is that of a slightly processed food (*14*).

The fresh pulp, the most common used part of the fruit, is obtained after:

• Leaving the whole fruit to dry on the tree, and then harvesting the dried fruits before crushing the fruit shells and separate the seeds from the pulp. The pulp is ground and sieved to produce a powder, and the powder is finally kept in convenient containers;

• But mostly after crushing the fruits shell, the baobab fruit pulp is directly sold in the market to people for some specific uses.

Most of applications of the baobab pulp could include the preparation of refreshing drinks and caillement of milk (Diop et al. 2006), and in some cases it can used for traditional therapy. Caluwé et al. (2010) has mentioned that when the pulp is soaked in water, it produces a milky solution which is then consumed as a milk substitute. This technique is used by urban area populations of Dakar and in many parts of countryside to produce ice creams. The funicles (in the mesocarp) mixed with the pulp in decoction produce herb tea good for amenorrhea (*3*) in comparison to Senegal tradition way this decocted solution is also used for curing some specific health troubles. These funicles, reported by Besco et al. (2007), showed more antioxidant capacity compared to the pulp alone (*3*).

1.2. Description and variability/similarity of processing methods

The description and processing methods used for baobab fruit in Senegal are represented in *figure 1*. Variability of processing is noted between producers (*5*).

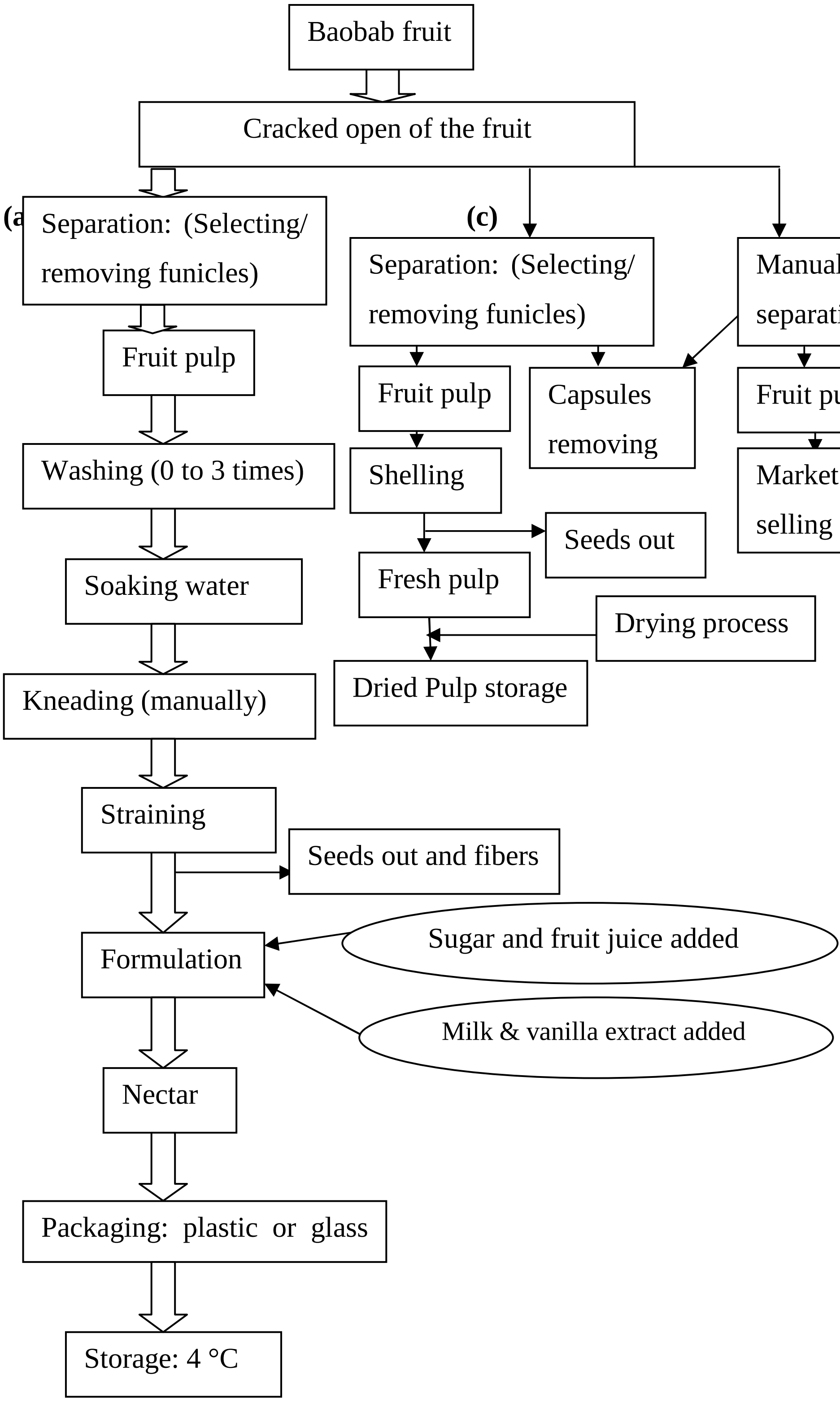


Figure 1. (a) Traditional processing of nectar and main variant after realized investigation on 93 persons' samples in Dakar urban zone and Saly in Mbour (Source: Cissé et al. 2009); **(b)** dried baobab pulp from Baobab Fruit Company Senegal; **(c)** baobab fruit pulp market selling

The different steps during the baobab fruit pulp processing are represented in *figure 2*:

Figure 2. Perfect microbial profile, harvested and transformed with inox patented technologies in special rooms

Source: Baobab Fruit Company Senegal retrieved from www.baobabfruitco.com

1.3.Major problems associated with processing methods

From results reported by Cissé et al. (2009), baobab pulp quality from Senegal is rapidly decreased because of a lack of caution during processing. The same conclusion was done by Chadare (2010) in which baobab pulp quality degradation was linked to vitamin C loss. Using water activity as a parameter, there is still work to do on combining the latter parameter with other usual parameters to minimize the vitamin C loss.

Vitamin C loss is the most important problem encountered by pulp producers. Also, the control of the browning reactions must be taken into account for better organoleptic characteristics.

Results from Cissé et al. (2009) show that drinks from baobab fruit pulp that are not stabilized have quality differences.

From these investigations, the washing and extraction step of the nectar from the baobab fruit pulp need to be improved in order to maximize soluble solids (SS) with satisfactory quality and improved shelf life. The need for pasteurization should be optimized such that it does not significantly alter the final quality (sensory and vitamins) of the product. In other words, the thermal pasteurization for stabilization of the nectar is needed. The improvement of the dried baobab fruit pulp quality ensures better use.

1.4. Storage methods, maximum duration and problems associated with storage

The storage condition of nectar from an investigation on 93 persons including 42 households, 27 sellers and saleswomen, 24 restaurateurs was done. Nectar was stored 1-7 days into plastic bottles at 4 °C. In spite of good microbiological results, modification of the flavor of pasteurized nectar was observed after 11 days (*5*). From the same results, the color and the flavor of stored nectar were altered by the pasteurization treatment. The vitamin C loss of 50-60 % was noticed during the storage condition (4°C) after 80-90 °C pasteurization treatment. Vitamin C can be adversely affected by moisture during storage or by heat during food preparation (*15*).

The organoleptic changes during storage can be due to browning reactions. In fact, most traditional producers did not have an adequate production line and good storage condition because of lack of equipments.

2. Socio-economic importance

2.1. Production, processing, handling and storage zones identified in the country

In Senegal, *A. digitata* (L.) plants are everywhere. Most of them grow around Dakar, Thiès and Kédougou regions. Elsewhere, the trees are found near villages or ancient hamlets, but rarely in soudano-guinean bush (*10*). According to the Senegalese Institute of Agricultural Research, the two main production zones of baobab fruit pulp are located in Kaolack (in the center of Senegal) and Tambacounda (the west part of Senegal) regions, notably in Kounguel-Kossanar and Bakel-Goudiri Salémata, Fongolembi and Kédougou. More disperse populations were exploited for fruit production in Thies (especially Nguekhokh and Tivaouane), Louga, Matam, and Saint Louis regions (*10, 16*).

2.2. Socio-economic profile of the actors

Baobab Fruit Company is a successful family firm, which markets very expensive finished products with specific health claims. It exports the baobab fruitfrom Senegal, where it has a subsidiary company, the Baobab Fruit Company Senegal. This firm mainly sells also the baobab fruit to other companies in smaller amounts (*2*). Small and middle enterprises as well as households produce nectars, ice creams and culinary foods with baobab pulp as the basis constituent or in some cases it is used as additive to local market, supermarkets, stores and cars station.

2.3.Socio-economic importance of the product

The pulp is largely the most important part in term of income from the baobab fruit. The separation of seeds and fibers from the pulp is done in different ways. One is using the dry method (which is a form of moderated grinding then sieving) to obtain a powder; humid way is another (soaking and kneading in water then sieving) to get liquid product with sticky consistence. The pulp is directly used as ingredients because of its binder, thickening, and acidifying proprieties (*3, 8, 10, 17*). The pulp is directly used as ingredient in many cereals preparations such as porridge and rolled flour products (for example, “Ngalax” in Senegal), sauces or ice trimmings. The pulp can be used to activate alcoholic fermentation of drinks. Finally, by adding water or milk (200-400g.L^{-1}), the baobab fruit pulp can be used as nectar rich in vitamin C or to make sorbet (*10, 18*). From Infoconseil, Paoa (2006), the harvested products including baobab pulp occupied a choice place on trade and consumption for classified legumes and fruits. The volume of exportation is still growing according to local and international markets.

2.4.Commercialization of the product

In Dakar market, the price of the baobab fruit pulp without the capsule (pulp + seeds + fibers) vary from FCFA.kg^{-1} 300 to 400 according to the season period (*10*).

The growth in the number of companies using baobab products is observed through the increased demand for raw materials. The Baobab Fruit Company implanted in the region of Thies exported 70 tons of raw material in 2003 and 140 tons in 2004, which correspond to 44 tons of fruit pulp and 83,000 € income. In Italy there is a growing interest for this product in the media, which indicates that this market will continue to develop in future. Another Italian company that uses baobab fruit pulp is Specchiasol, which manufactures a symbiotic health product (symbiotics, wich are products which combine the two biotic claims). The target group for the Baobab Fruit Company is primarily the Italian niche market. The market for baobab fruit pulp is not saturated and there are more possibilities that the Baobab Fruit Company have not exploited, such as a natural ingredient for the food industry (*2*). Figure 3 shows a general international trade for the baobab fruit pulp to Europe.

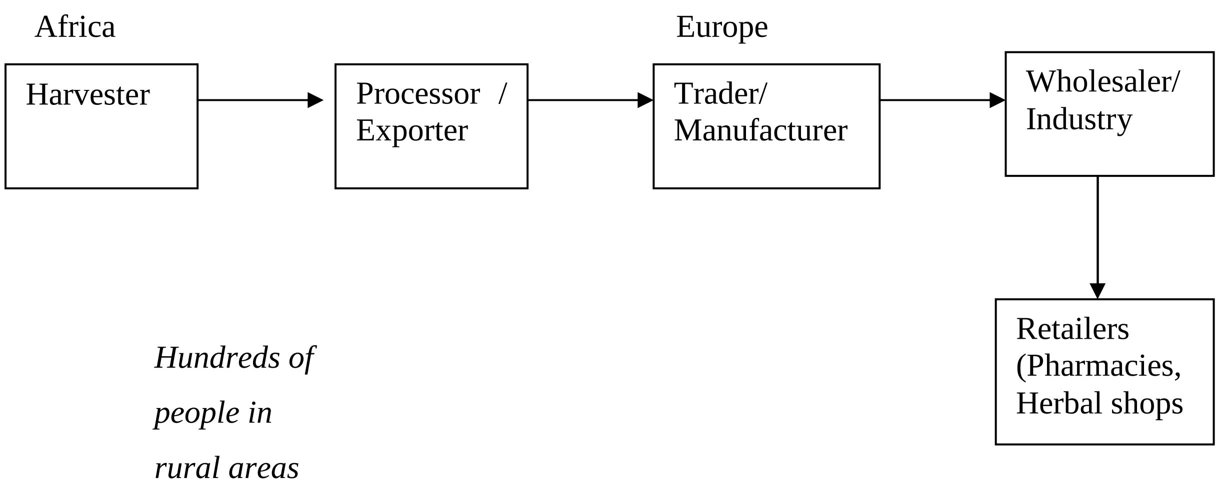


Figure 3. Supply Chain for Baobab Fruit Pulp

Source: Gruenwald & Galizia (2005)

3. Quality characteristics of the product

The quality characteristics are linked to some intrinsic and extrinsic parameters that govern the food products.

3.1. Nutritional quality

The pulp is very nutritious. The pectin in baobab fruit pulp is mainly water soluble and has a low degree of esterification and a low intrinsic viscosity. This suggests that it will probably not yield a high quality jelly of high solids content, because it tends to precipitate rapidly in acid media to form irregular gels. It is of lower quality than commercial apple pectin and citrus waste pectin (*7*). According to Caluwé et al. (2010), about 35.6% of the total carbohydrate content is represented by simple sugars in baobab pulp. This explains the noticeable sweet taste of the pulp. However, the sweetness may vary for different types of pulp (*19*). The low water content, strong acidity and high sugar content was confirmed by

Cissé et al. (2009). The reported proximate composition of baobab fruit pulp differs according to different literature sources with some authors reporting that there is no starch in the pulp (*7*). According to Chadare et al. (2009), consumption of 100 g pulp will cover 26 to 50% of the carbohydrate recommended daily intake (RDI) for pregnant women. From the same authors, 21.5% to 40.6% of the RDI is achieved when 60g is consumed by child between 4 and 8 years.

The consumption of 20 g baobab pulp covers an average 194% of the RDI for children (4-8 years) (*20*). Additionally, vitamin C aids the bodily uptake of iron and calcium, of which the fruit pulp contains more than double that found inin an equal amount of milk (*2*). Therefore, in some Senegalese weaning food, the baobab pulp is used as a milk substitute for babies. The baobab pulp is also a good source of vitamins B1, B2, B6 and A (*10*).

The baobab fruit pulp is particularly high in the amino acids valine, tryptophan and phenylalanine and tyrosine. Linoleic acid is the most abundant fatty acid in the pulp (*7*).

The pulp is relatively rich in dietary fibers (7g/100g average), but the reported values vary from one author to another (*10*).

Baobab fruit pulp, due to the combination of health claims (such as anti-oxidation properties, high calcium content, and anti-inflammatory effect) and food technological functions (due to its high pectin and fiber content, baobab fruit pulp gives beverages a thicker consistency and can be also used as filler), is a very interesting candidate for a new generation of functional foods and drinks (*21*).

3.2. Microbiological quality

The baobab fruit pulp has been reported to have the following microbiological count:s lactic bacteria (1,2 – 3,7 × 10^3 UFC·g^{-1}), yeast (<10 UFC·g^{-1}), molds (4,0 × 10 2 – 2,0 × 10^3 UFC·g^{-1}), salmonellas (absent in 25 g of sample size), coliform bacteria (<10 UFC·g^{-1}) (*5*).

Furthermore, soluble dietary fiber, such as that found in the baobab fruit pulp (about 25%), is known to have prebiotic effects, which means they stimulate the growth and/or the metabolic activity of beneficial organisms (*2, 21*).

3.3.Physico-chemical and sensory characteristics

The pulp represents 14-28 % of the total fruit mass (*10, 22*) .

Arnold et al. (1985) reported that with an average of 8.7% moisture, the pulp contains about 74% carbohydrates, 3% proteins, 9% fibers, 6% ash and only 0.2% fat. The content of pectin is approximately 52-56% (*7, 23*), making the pulp traditionally used as a base for jam making.

It is also characterized by a high vitamin C (ascorbic acid), calcium, phosphorus and potassium content (*2*).

Independently of the variation in reported values, the data reveal high vitamin C content of the pulp (169-980 mg/100g) (*3, 20*). The content of 169,0 mg/100g vitamin C in the baobab fruit was found, and compared with 106,0 mg/100g for fresh chillipepper (*15*). While for Gruenwald & Galizia (2005), only 75.6 mg/100g was found.

Table 1 Analysis of most important components in Baobab Fruit Pulp

Bio-chemical components	Contents (mg/100g)
Protein	2.3
Lipids	0.27
Soluble and insoluble Fibers	52.0
Ascorbic acid (Vitamin C)	75.6
Calcium	280-300 (to compare: 51 in oranges**)
Potassium	293 (to compare: 125 in milk**)
Phosphorus	2.31
Phosphorus	96-118

Source: Gruenwald & Galizia 2005

The pulp is acidic, with an average pH 3.3, due to the presence of the organic acids citric, tartaric, malic, succinic and ascorbic. As previously mentioned, the pulp is also rich in fibers (average 7%). The fruit pulp contains a high amount of carbohydrate, low protein, and extremely low fat (*7, 24*).

The most important sensory characteristic of the baobab nectar that have been searched for include color, taste and flavor (*5*). Due to many difficulties, the sensory attributes are really compromised by lack of processing facility as well as the byproducts storage in the ready to sell nectar in different areas.

3.4.Product quality perception/requirement by consumers

The quality perception/requirement by consumers depends on the type of byproducts of the baobab pulp mixture with or without other food. For the baobab nectar and pulp, the most important perception is the taste, the appearance and sometimes the flavor. People like baobab

pulp’s ice cream with a milk-yogurt taste. This is the reason why milk yogurt is usually added.
Dietary fiber isknown to be essential in food because of its physiological effects on the human digestive system. The insoluble dietary fiber, which is not assimilated by the intestines, speeds up the intestinal transit time, which in turn increases the amount of stool, thus reducing constipation. At the same time dietary fiber gives a sense of satisfaction, thus reducing food intake. The high amount of fiber in baobab pulp is of particular interest, especially when it relates to in to intestinal microflora’s capacity to deal with other bacteria. The studies done on the soluble fibers highlighted the hypothesis of its prebiotics use, which means that, as a food ingredient that is not assimilated, it can stimulate metabolic activity of limited number of microorganisms (Roberfroid 2008, Mason 2007, Klinder et al. 2008, Henryk 2008).

Furthermore, some recent studies have showed that the complete plant (pulp, leave, fibers), has important antioxidant activity, and this may lead to the prevention the of free radical formation and also reducing them, when present he fruit pulp of *A. digitata (L.*) has been compared using photochemiluminescence, with other fruit pulps which include orange pulp, grape pulp, blueberry pulp, and kiwi pulp. The results showed that its integral antioxidant activity is higher than the fruits cited above (Besco et al. 2007). The use of functional food is still growing in Senegal as happened in European countries.

4. Consumption forms of the product

4.1. Food forms

The different ways of using baobab fruit pulp in Senegal are:
Fruit powder mixed with water and milk yogurt is used with sticky rolled flour porridge especially during the naming ceremony and other events. The mixture is also used with steam rolled millet flour called in local name “Ngalax”; in other way, the fruit baobab pulp is soaked and kneaded in water to make a nectar (*figure 4*) used in the same way as described below;
Also the fruit pulp of baobab is very prized for some culinary use, sauces and food additive;
Drinks can be prepared by adding fruit pulp powder to water or making a decocted fruit pulp. The final solution is mixed with sugar, milk, vanilla extract and fruit juice to produce nectars properly packed in plastic bottles as described by Cissé et al. (2009).

Figure 4: Preparation of baobab fruit pulp nectar in traditional way: (1-2-3) pulp, seeds and fibers are diluted in water; (4) seeds and fibers are removed (4a) and dissolved pulp remains (4b) (Source: Caluwé et al. 2010)

4.2. Period of the day for consumption

During the breakfast of the naming ceremonies, a mixture of baobab pulp nectar with yogurt milk on rolled flour millet sticky porridge is very much appreciated by Senegalese people. Most of time, people commonly enjoy baobab pulp nectar after eating a very nice fatty rice and fish “tiebou dien”. However at dinner time, people prefer “Ngalax” which is steam rolled millet flour mixed with baobab pulp nectar, peanut butter and yogurt milk containing some dried grapes and many additives according to personal choice. Also poured mixture of baobab pulp nectar with yogurt milk on rolled flour millet sticky porridge is mostly consumed at dinner. The baobab pulp is also used to acidify food.

5. Research activities and new development on technology and product

The references on baobab fruit pulp processing or the impact of treatments on final products quality are rare (*5*).

In the functional food category, functional beverages are the fastest growing segment. In the forefront of consumer interest, are substances with anti-aging properties, energy supplying, relaxing, or beauty enhancing effects (*25*). The pulp and nectar of baobab fruit pulp can be assumed as natural and functional food category because of the high antioxidant activity from the vitamins (C, B, A) and the all kind dietary fibers that they contain. They offer a wide range of active components and functions because of the mineral compounds present in high quantities.

There is also an increased preference for plant ingredients over animal derived ingredients, but they should be organic, not merely natural. As a consequence, medicinal plants used traditionally in Europe have found their way into beverages in small amounts, lending not only new taste, but also the appeal of a health-promoting ingredient, even if their concentration is insufficient for any actual pharmacologic effect. Another trend is the increasing consumer interest in ethnic and traditionally used products. Baobab is one example of plants used in new products that have recently entered the market (*25*). In this way, the look of trends to develop new products and to improve the traditional African food becomes the right way to be exploited for many reasons .

The added value baobab fruit products for the traditional market are limited to drinks destined for the local market. These products are mostly not shelf stable, and have a storage life of a few days. The baobab products are well liked by the local population for their organoleptic characteristics. It is important to evaluate the potential of technology in the development of products destined for the local, regional, and international markets.

A good opportunity is to make some comparison research between the most important species (leaves, seeds, pulp and tubers) used in Madagascar (*Adansonia za*) with the *Adansonia digitata* we have in Senegal. Furthermore, to my knowledge no data is available on *A. za* on the physico-chemical and biochemical composition or processing technology of any products from this specie. An open way for results to be exploited will be a concern.

Conclusion

The perspectives on research and innovations researches can be divided in different ways, as follows:

More appropriate extraction methods (under vacuum) of baobab pulp are still needed to obtain high concentration, as well as in order to minimize deterioration of the pulp nutritive value as recommended by Abdalla et al. (2010). It would be an advantage to use different drying methods, that can targe for the preservation of bioactive components, safety and added value products;

To my knowledge no research has been done on the possible increase in value of bioactive components by processing technology, in this way the use of microencapsulation of some specific health-benefitting bioactive components can be investigated;

A research focused on the thermal stabilization of local nectar production from baobab fruit pulp is a promising area as concluded by Cissé et al. (2009). These results will increase shelf life of the baobab fruit pulp drinks and also will boost the economic profit margin for enterprises in this area for exportation possibility. As noticed, the baobab fruit nectar is easy to be destabilized because of instability due to fibers, some specific fructo-oligosaccharides and glycosides which easily sediment or ferment producing taste and flavor changing. The use of specific enzymes will help to partially remove /decrease these components (/sizes) cited below for the stability suspension;

Dried baobab fruit pulp is the most important product used in trade marking, but still needs research on the vitamin C conservation as recommended by Haddad (2010). The research on kinetic factors (pH, temperature and time) combined with water activity will help a lot on improving the vitamin C loss;

Nowadays enzymes are the key factors for juice stability improvement; hence the optimization of processing parameters for natural baobab fruit pulp nectar using specific enzymes will be good opportunities for juice and syrup yield increasing, stability and organoleptic enhancement (polyphenols, soluble fibers and others). As we know fruto-oligosaccharides are easily fermented especially in baobab fruit pulp in which bacterial micro flora can start the fermentation process. The enzymatic stabilization can be experimented;

Berlinet et al. (2007) reported that the lower the pulp concentration in orange juice the higher the aroma lost after ultra high temperature (UHT) pasteurization (20 sec at 98 °C). Hence study is necessary on this topic for a good preservation of baobab fruit pulp syrup and nectar;

More research is needed on the enzymatic browning and non enzymatic browning reactions to reduce the undesirable organoleptic quality change of final products;

The beneficial effects of baobab dietary fiber on some microorganisms need to be retained during processing. The optimization of the processing parameters will help to achieve this.

Reference:

1. Diop, A. G.; Sakho, M.; Dornier, M.; Reynes, M.; Diop, C. G. M.; Sock, O. In *Fruit du baobab; etude de la transformation de la pulpe en nectar*, Maîtrise des Procédés en vue d'améliorer la qualité et la sécurité des aliments, Utilisation des OGM, Analyse des risques en agroalimentaire, Ouagadougou, 2005; Ouagadougou, 2005.
2. Gruenwald, J.; Galizia, M. In *Adansonia digitata L. Baobab*, United Nations Conference on trade and development, 2005; UNCTAD /DITC/TED: 2005.
3. HADDAD, C. Fruits chauvage du Senegal. Universite de Montpellier 1, Montpellier, 2000.
4. Ambroise-Oji, B.; Mughogho, N., Adansonia Baill. In *Huiles végétales/oléagineux*, Vander Vossen, H. A. M.; Mkamilo, G. S., Eds. PROTA: Wageningen, 2007.
5. Cissé, M.; Sakho, M.; Dornier, M.; Diop, C. M.; Reynes, M.; Sock, O., Caractérisation du fruit du baobab et étude de sa transformation en nectar. *Fruits* **2009,** 64, 19-34.
6. Gebauer, J.; El-Siddig, K.; Ebert, G., Baobab (Adansonia digitata L.): a Review on a Multipurpose Tree with Promising Future in the Sudan. *Gartenbauwissenschaft* **2002,** 67, (4), 155-160.
7. Caluwé, E. D.; Halamová, K.; Damme, P. V., Adansonia digitata L. – A review of traditional uses, phytochemistry and pharmacology. *afrika focus* **2010,** 23, (1), 11-51.
8. Sidibe, M.; Williams, J. T., *Baobab Adansonia digitata L.* International Centre for Underutilised Crops: Southampton, 2002; p 96.
9. Anon *Le Baobab. Fiche technique*; Fond Natl. Rech. Agric. Agroaliment. (FNRAA) Sénégal: Dakar, 2003.
10. Diop, A. G.; Sakho, M.; Dornier, M.; Cissé, M.; Reynes, M., Le baobab africain (Adansonia digitata L.) : principales caractéristiques et utilisations. *Fruits* **2005,** 61, 55-69.
11. Yazzie, D.; Vanderjazt, D. J.; Okolo, D.; Glew, R. H., The amino acids and mineral content of baobab (A digitata. L) leaves *Journal of Food composition and analysis* **1994,** 7, (3), 189-193.
12. Editorial, Food powder technology. *Journal of Food Engineering* **2009,** 94, 129.
13. Obizoba, I. C.; Anyika, J. U., Nutritiva value of baobab milk (gubdi) and mixtures of baobab (Adansonia digitata L.) and hungry rice, acha (Digitaria exilis) flours". *Plants Foods Hum Nutr* **1994,** 46, 157-165.
14. Vertuani, S.; Braccioli, E.; Buzzoni, V.; Manfredini, S., Antioxidant capacity of Adansonia digitata fruit pulp and leaves. *Acta Phytotherapeutica* **2002,** 2, 2-7.
15. Sidibé, M.; Scheuring, J.; Tembely, D.; Sidibé, M. M.; Hofman, P.; Frigg, M., Baobab -homegrown vitamin C for Africa. *Agroforestry Today* **1996,** 8, (2), 13-15.
16. Kerharo, J.; Adam, J. G., *La pharmacopée Sénégalaise traditionnelle. Plantes médicinales et toxiques*. Editions Vigots fréres: Paris, 1974; p 1011.
17. Kenne Fopa, O. Contribution à l'étude de l'activité antidiarrhéique de la pulpe de fruit de Adansonia digitata L. (Bombacacae). Univ. Cheikh Anta Diop, Dakar, 1994.
18. François, M., *Transformer les fruits tropicaux : guide technique*. GRET: Paris, 1993.
19. Chadare, F. J.; Linnemann, A. R.; Hounhouigan, J. D.; Nout, M. J. R.; Van Boekel, M. A. J. S., Baobab Food Products: A Review on their Composition and Nutritional Value. *Critical Reviews in Food Science and Nutrition* **2009,** 49, 254-274.
20. Chadare, J. C. Baobab (Adansonia digitata L.) foods from Benin: Composition, processing and quality. Wageningen University, Wageningen, 2010.
21. Abdalla, A. A.; Mohammed, M. A.; Mudawi, H. A., Production and Quality Assessment of Instant Baobab (Adansonia digitata L.). *Advance Journal of Food Science and Technology* **2010,** 2, (2), 125-133.

22. Favier, J. C.; Ireland-Rippert, J.; Laussucq, C.; Feinberg, M., *Répertoire général des aliments Tome 3. Table de composition des fruits exotiques, fruits de cueillette d'Afrique*. Lavoisier: Paris, 1993.
23. Nour, A. A.; Magboul, B. I.; Kheiri, N. H., Chemical composition of baobab fruit (Adansonia digitata L.). *Tropical Sciences* **1980,** 22, 383-388.
24. Osman, M. A., Chemical and Nutrient Analysis of Baobab (Adansonia digitata) Fruit and Seed Protein Solubility. *Plant Foods for Human Nutrition* **2004,** 59, 29-33.
25. Gruenwald, J., Novel botanical ingredients for beverages. *Clinics in Dermatology* **2009,** 27, 210-216.