ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 02, pp.1007-1012, February, 2019

DOI: https://doi.org/10.24941/ijcr.34267.02.2019

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

PROCESS OF PRODUCTION AND VALORIZATION OF *SUMBALA* AN AFRICAN MUSTARD: A REVIEW

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ARTICLE INFO

Article History:
Received 15th November, 2018
Received in revised form
08th December, 2018
Accepted 04th January, 2019
Published online 28th February, 2019

Key Words:
Sumbala, Process, Fermentation, Valorization, Probiotics, West Africa.

ABSTRACT

The sumbala or African mustard, produced by traditional methods of fermentation of some protein and/or oleaginous seeds, is a food condiment used in West Africa. The variability of its organoleptic characteristics led to diversity of product and makes its more complex for characterization. Several studies have provided information on the process of this condiment production, it's an important source of nutritional values as well as its nature and microflora properties. Organoleptic characteristics of this condiment were also reported. Through this study, current knowledge about the product and the process of production as well as technology and responsible bacteria involved in this type of fermentation have been discussed.

***Citation: Roukaya Abdou Souley, Issoufou Amadou, Halima Diadie and Abdourahamane Balla.* 2019.** "Process of production and valorization of sumbala an african mustard: A review", *International Journal of Current Research*, 11, (02), 1007-1012.

INTRODUCTION

Fermentation is a metabolic process that produces chemical changes in organic substrates through the action of microorganisms (enzymes). It is form of food preservation and improve food nutritional and organoleptic qualities (Omobolanle, 2018); in addition, it allows food diversities (Amadou *et al*., 2011). The condiments are substances intended to season that is to say to raise the taste of food or culinary preparations including sauces. The condiments are on the market either prepare or raw. Usually, in sub-Saharan Africa, many condiments of food flavorings are prepared through traditional methods of fermentation; most often of plant origin, it can be of animal origin or mineral as well (Mtasher *et al*., 2018 and Roberfroid, 2000). *Sumbala* or African mustard is a condiment used widely across sub-Saharan Africa. These condiments are produced from a process of alkaline, traditional and uncontrolled fermentation of seeds from some plants such as *Parkiabiglobosa, Pentaclethra macrophylla* Bentham, *Hibiscus sabdariffa* or even *Arachis hypogeae* (Ibrahim, 2011;Olagunju *et al*., 2018). It is usually prepared by women over the course of several days, traditionally from *P. biglobosa* seeds.

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Several researchers reported the microbiological characterization of some of these traditional fermented condiments that highlighted the involvement of lactic bacteria and yeast in the process of natural fermentation (Paul *et al*., 2018).Lactic acid bacteria are known for natural inhabitants of the gastrointestinal tract of animals and humans. *Sumbala* processing are income generating activities and allow women in particular facing food insecurity problems become very recurrent in the countries of sub-Saharan Africa (Olagunju *et al*., 2018). Despite the importance that these activities play in the socio-economic development of these countries, many of them remain or belong to the informal sector (Cheyns, 2003; Suresha, 2018). Despite the predominance of its artisanal and informal production system and the growing urbanization of the population lead to a willingness to look for opportunities to improve the quality of these products through a system of standardization of the methods. This work aimed to overview the present state of processing and valorization of *sumbala* as well as the technological and functional properties of bacteria involved in this natural fermentation, vis a vie the development of this traditional food in sub-Saharan Africa.

African mustard: *Sumbala* is the name of African mustard in a popular Manding language in West Africa meaning food condiment in the tradition of that area people, it is prepared from the seeds of the African locust beans or *P. biglobosa*

(Cheyns and Bricas, 2003). Because of its origin, the *sumbala* means the fermented seeds of the African locust beans (Ojewumi, 2018). In the recent time, facing the effects of climate change and increasing population growth, the availability of the locust plantations become increasingly rare. The population is forced to substitute these seeds of origin by those of roselle or Guinea Sorrel (*H. sabdariffa*), baobab (*Adansoniadigitata*) and soybean (*Glycine max*) more available and affordable in the region (Ojewumi, 2018; Parkouda *et al*., 2009). In addition, these plants seeds showed their performance in the production of the *sumbala* as witness by various producers of this condiment across the sub-Saharan countries (Ojewumi, 2017). Apart the popular name *sumbala* it also has various names depending on the sub-Saharan country and the raw materials that served in its production. In this case, names such as *Dawadawabatso, Kinda, Bikalga, Furundu, Datou, Mbuja, Yanyanku/Ikpiru, maari* are found in those region (Ibrahim *et al*., 2011; Camara *et al*., 2016). Furthermore, it should be noted that production still traditional, carried out mostly by the women and technical skills and know how are based on traditional knowledge and experience, which is transfer from generation to generation as far as it is family business (Suresha, 2018). however, it is found that some sumbala producers make use of some additives or combine raw materials in aim of improving the organoleptic quality of their products (Cheyns and Bricas, 2003).

Description of *sumbala* production process from *P.biglobosa* and *H. sabdariffa* seeds: *Parkiabiglobosa*, also known as the African locust bean or néré or dodongba, is a perennial deciduous tree of the Fabaceae family. It is found in a wide range of environments in Africa and is primarily grown for its pods that contain both a sweet pulp and valuable seeds. The pods are pink brown to dark brown when matured; they are up to 45 cm long and 2 cm wide. Each pod contains up to 30 seeds embedded in a yellow pericarp. The seeds are relatively large with an average weight of 0.26 g and have a hard test (Agroforestree Database, 2008). Roselle (*Hibiscus sabdariffa*) is a species of Hibiscus probably native to West Africa, used for the production of best fibre and as an infusion, in which it may be known as carcade. It is an annual or perennial herb or woody-based subshrub, growing to 2–2.5 m (7–8 feet) tall (Achir *et al*., 2019). Based on the works of Parkouda *et al*. (2009); Ibrahim (2011) and Camera (2016), the African mustard or *sumbala* of the *P. biglobosa* and *H. Sabdariffa* production process are known to be on the traditional techniques of alkaline fermentation of these seeds. Though, these technological processes have specific geographical features according to the ethnic group of producers, locations and type of desired product (Azokpota *et al*., 2011; Zannou *et al*., 2018). The variation in *sumbala* processes were observed from different environmental conditions and ethnic groups in addition to the type of raw materiel used and local tradition (Parkouda, 2009). The time spent in *sumbala* production depends on the strategies deployed by each producer in accordance with trading specification or storage experience. The *sumbala* (Figure 1) production process includes four major steps: treatment of seeds, cooking of the clean seeds; fermentation of cooked seeds and transformation of fermented mustard seeds. Each of these steps is carried out using a series of complex and laborious unit operations.

Cleaning of P.biglobosa and H. sabdariffa seeds: The cleaning of the seeds is an important step in the process of producing this mustard of *P. biglobosa* and *H. sabdariffa*. According to Parkouda *et al*.(2008), it is a step that determined the hygienic quality of the finished product. This step involves sorting, pounding, winnowing and washing. This is more complex with *P. biglobosa* seeds that contain an almond which is covered with a thin dark layer and a very hard shell. However, only softening of the husks of the seeds could make the almond available (Azokpota *et al*., 2006).

Softening of the husks of the seeds: According to the *sumbala* producers, two types of unit operations are involved in softening the hull, boiling and soaking of the seeds. Though, scalding seems to provide more time saving as the most common thermal pretreatment compare soaking even though it requires a strong energy consumption such as firewood in pure traditional ways. The unit operation of soaking takes at lasts 48 h to 72 h depending to the degree of maturity of the seeds and origin (Oguntoyinbo *et al*., 2007). It was reported that some producers use a potash solution to conduct the dipping of the seeds (Ouoba *et al*.,2010); in mind to save time and energy, producers prefer sometimes to combine the two techniques (Cheyns and Bricas, 2003).

Extraction of the P. biglobosa almond: One of the most difficult step of sumbala production process is the almond of the *P. biglobosa* extraction through the operation of shelling the seed teguments made friable (Koura *et al*., 2014). Knowing how painful it is the two identified methods of dehulling from where *sumbala* production is predominant, first is pounding and treading mixt with sand and ash. The abrasive action of the sand facilitates the dehulling and the ashes make almond less brittle and more resistant to the effect of friction exerted during the process. Then the extraction of the almond, is done by washing off the impurities (envelopes, residue ash and added sands).

Cooking of H. sabdariffa seeds and purified P. biglobosa almond: After cleaning of roselle seeds and purified African locust beanalmond the next is cooking in an alkalized water to soften during 2 h for locust bean almond and 10 to 12 h for roselle seeds the timing depends on the energy used and softening agent added (Oguntoyinbo *et al*., 2007).The cooking of roselle seeds, seems to be the more laborious as step, even though long-time cooking requires permanent monitoring and special attention to the process. According to Ibrahim *et al*. (2011), the great difficulty of this step lies on the energy and time consumption.

Fermentation of H. sabdariffa seeds and cooked P. biglobosa almond: This step requires little work, yet very important in large to determine the organoleptic quality of the finished product (Cheyns and Bricas, 2003). The duration of fermentation varies according to the methods, the producers, the desired final product ammonia concentration and the type of seeds (Parkouda, 2008; Parkouda et al., 2009; Ibrahim *et al*., 2011; Agbobatinkpo, 2013). In this line, the fermentation of *sumbala* of the *P. biglobosa* almond lasts for 48 h or likely more for the Nigerian *dawadawa* (Odunfa, 1985), 18 h for the *afitin* of the Benin (Azokpota *et al*., 2006), 72 h for the *netetu* Senegalese (Ndir *et al*., 1994). According to the communities, this is done in covered gourds with jutes bags or in the pots covered with the leaves of banana trees (Cheyns and Bricas, 2003). As for the *H. sabdariffa* seeds, some producers leave the product tightly closed during 3 to 4 days to promote the development of a slight ammonia smell (Parkouda *et al*., 2008; Ibrahim *et al*., 2011).

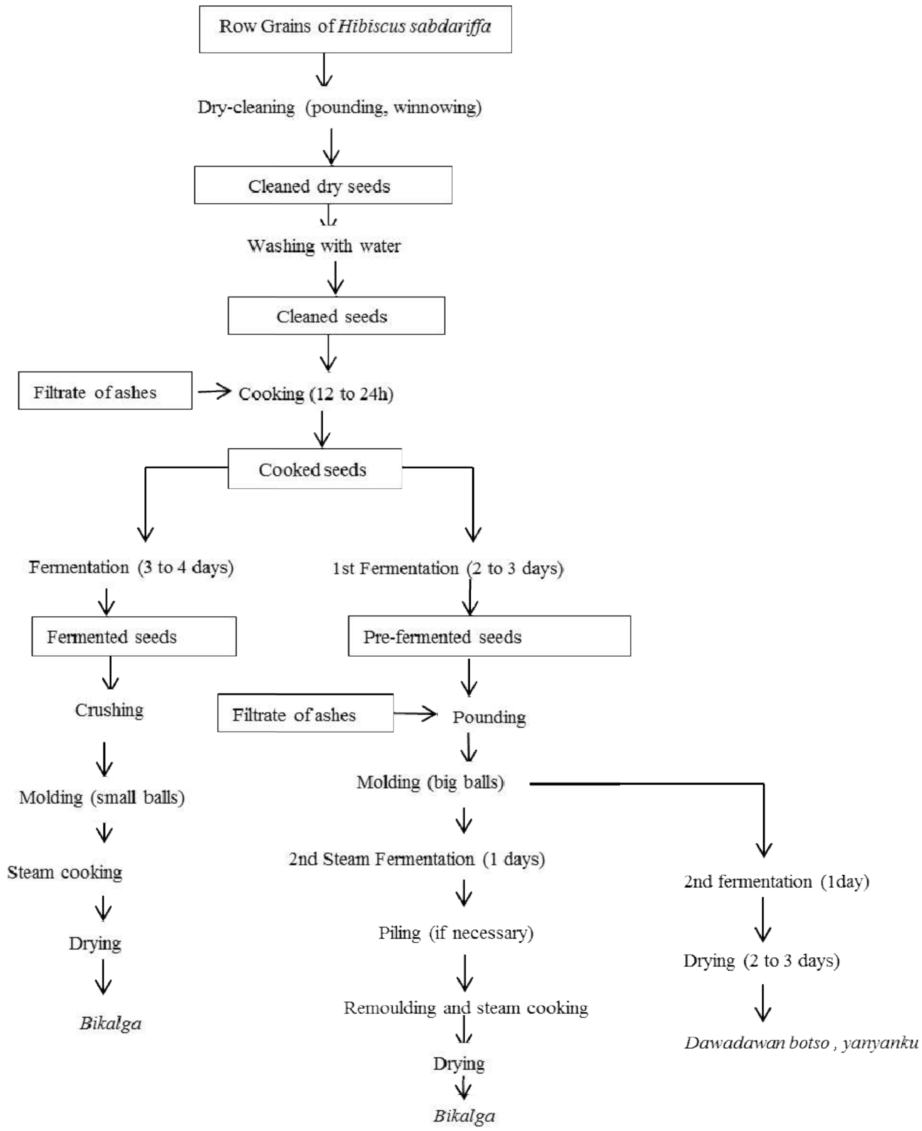

Figure 1. Flowchart of *sumbala* processing (Parkouda *et al*., 2008; Azokpota *et al*., 2011; Ibrahim *et al*., 2011, 2008)

Figure 2. *Sumbala* of roselle and African locust beans (Lamien *et al*., 2011)

Other producers make out the product after 2 to 3 days to achieve operation of pounding with added potash solution, before continuing the fermentation for 1 to 2 days. This second technique allows to obtain a final product with strong smell of ammonia (Parkouda *et al*., 2008; Ibrahim *et al*., 2011). In addition, to optimize the fermentation conditions some producers, make use of *Lanneamicrocarpa* leaves or a layer of ash over the cooked roselle seeds (Parkouda *et al*., 2008).

A non-successful fermentation can lead to a non-addible *sumbala* product.

Obtainingroselle seeds and fermented African locust bean almond into sumbala: At the end of fermentation, fermented seeds and almond undergo a series of technological treatments based on the know-how of the producers and the desired end product. For obtaining the mustard of *H. sabdariffa* in most areas, the fermented seeds with second fermentation process are directly sundried for different time depending on the seasons (Parkouda *et al*., 2008; Ibrahim *et al*., 2011). However, the fermented seeds from the first process must first be pounded before the operation of drying (Parkouda *et al*., 2008; Ibrahim *et al*., 2011; Agbobatinkpo, 2013). Moreover, some producers use a technique of steaming for a period of 2 to 3 h before the operation of drying (Bengaly *et al*., 2005). According to Bengaly *et al*., 2005, this cooking process developpes better organoleptic characteristics to the finished product and also increases its shelf life (Figure 1). Once dried, the fermented seeds are packaged in jutes bags or plastics. When it comes to *P. biglobosa* mustard, fermented almond present almost all of the organoleptic characteristics of the African mustard (Cheyns and Bricas, 2003 and Parkouda *et al*., 2009). The product is pasty, fragrant, covered with a mucilaginous filamentous coating giving it a color black brown and accompanied by a strong smell of ammonia. To maintain and improve the organoleptic properties, each producer uses its own tips according to local traditions. However, the drying operation is common to all of the different existing variants, that allows to extend the shelf life of the finished product (Figure 2).

Constraints of traditional *sumbala* process: The traditional production of *H. sabdariffa* and *P. biglobosa* mustard faces many forms of constraints that threaten the survival of its activity. According to Oguntoyinbo (2007), the technological deficit characterizing the traditional manufacturing processes of *sumbala* relate on the one hand the tedium of operations and other shortcomings in compliance with the hygiene rules in the entire chain of production. Ouoba (2010) noted also, low production due to the use of rudimentary equipment and high consumption of firewood. In addition, Chyens and Bricas (2003) and Camara (2016) showed out that apart these constraints, the declining popularity of these condiments, especially in urban areas is one of the causes. Indeed, the urban population engages more and more into imported foreign flavorings and soup "broths and culinary cube" (Chyens and Bricas, 2003). According to Koné (2001), the success of these 'cubes' lies not only in their taste power, but also the attractive price and their convenience. In order to increase supply and to deal with this growing competition, it is necessary to modernize production techniques and optimize processing conditions of *sumbala* (Ojewumi, 2018, 2001; Adedeji, *et al*., 2017).

Organoleptic, nutritional and microbiological values of *sumbala:* *Sumbala* fermentation involves a real microbial "machinery"; through their numerous lytic activities (proteolytic, amylolytic, lipasic, phytase, etc.) (Amao *et al*., 2018; Fatoumata *et al*., 2016) Naturally, fermentation with such microorganisms modify the biochemical, nutritional and sensory characteristics of product (Amadou *et al*., 2019). These changes are observed on the chemical composition, microbiological and taste of the final product.

Sumbala sources of probiotics: Probiotics (from the Greek "Pro-bios" meaning for life) refers to living microorganisms which, ingested in sufficient quantities, have a beneficial effect on the health of the host (Gu, and Roberts, 2019). To be designated probiotics, microbial strains must also meet a number of properties (security, functional and technological) and criteria for selection (McKenzie, 2018; Huang *et al*., 2017; ChabiIfagbéni, 2016). As well, it is known as the main probiotic microorganisms to date are bacteria: *Lactobacilli, Bifidobacteria, propionibacteries, Escherichia coli* and Enterococci and yeast (*Saccharomyces boulardii*) (Humblot, 2015). ChabiIfagbéni (2016) reported that probiotic bacteria are mainly the lactic bacteria and Bifidobacteria. In addition, they are the most studied and most widespread in human nutrition (Humblot, 2015). Many researches shown the characterization phylogenetic and functional of the microflora of the African mustard (*H. sabdariffa* and *P. biglobosa*) on probiotics. Oguntoyinbo *et al*. (2007) studied the antimicrobial activities secreted by *B. subtilis* and *B.pumilus*isolated from *sumbala* DGs inhibit and inactivate Gram-positive bacteria and Gram-negative as well as the fungi producing Ochratoxin A, during the culture in laboratory and natural fermentation. The work of Compaoré *et al*. (2013) on the antimicrobial substances of the predominant strains *B. subtilis* and *B. licheniformis* isolated from *bikalga* have also shown that the *B. subtilis* have inhibition capacity on the pathogenicGram positive and negative microorganisms such as *B. cereus, Salmonella spp., L.monocytogenes, Y. enterocolitica, M. luteus and S. aureus.* However, *B. licheniformis* inhibit the*M. Lueus*. The gene coding for the antimicrobial activity of *B. subtilis* is responsible for the synthesis of the following metabolites: subtilin, subtilosin, surfactin, pliplastatin (Compaoré *et al*., 2013).

Nutritional values: The bioactivities of the noted microorganism species involved in the *sumbala* alkaline fermentations possess led to the formation of various bioactive compounds such as fatty acid and peptides (Gernah *et al*., 2007). Analysis of the free fatty acid composition of unfermented and fermented néré seeds revealed that 89.8% of saturated fatty acids, 8.9% of polyunsaturated and monounsaturated fatty acids are present in unfermented seeds. While these percentages are respectively reduced to 39.2%, 44.7% and 15.5% in the *nététu* (N'dir *et al*., 2000). Thus, N'dir *et al*. (2000) and Parkouda *et al*. (2009) concluded that the drop-in lipid content of the seeds after fermentation indicates the presence of this activity. Ouoba *et al*. (2003) have also shown that this lipolysis is a function of the species and the bacterial strain used as strain in the fermentation such as *B. pumilus* with higher lipolytic activity than *B. subtilis* isolates. In addition, Ndir *et al*. (2000) and Ouoba *et al*. (2003) also reported the presence of palmitic, stearic, arachidic, behenic, lignoceric, linolenic and gadoleic acids and high concentrations of linoleic and oleic in the *nététu* and *sumbala*. According to Parkouda *et al*., (2009), the presence of linoleic and oleic acids that can be converted to polyunsaturated fatty acids increases the nutritional value of the products since they are essential for human nutrition. In addition to proteolysis and lipolysis, microorganisms also hydrolyze non-digestible carbohydrates as a result of the amylases they release to produce energy (Parkouda *et al*., 2008 and 2009). In production trials conducted by Ouoba *et al*. (2005), Bacillus spp. produce amylase, galactanase, galactosidase, glucosidase and fructofuranosidase. All of these enzymes are involved in carbohydrate degradation during alkaline fermentation. In addition, Benghaly *et al*. (2005) and Parkouda *et al*. (2008) reported that there is a sharp decrease in total carbohydrate levels of about 50% in *bikalga* compared to unfermented roselle seeds. This process acts on the texture of the product by softening the tissues of the substrates (Amadou *et al*. 2009; Ouoba *et al*., 2007). *Iru*-a condiment produced from the fermentation ofthe dried, dehulled boiled seeds of African locust beans tree- *P.biglobosa*, which is a perennial leguminous tree of the sub-family *Mimosoideae* family

Leguminosae. Amao *et al*. (2018) reported that it exists significant difference in the free amino acids value between the *iru* fermented with both *Staphylococcus* spp and *Bacillus* species of bacteria and the one fermented with *Staphylococcus* spp. alone. Furthermore, no difference in amino acid content between *Staphylococcus* spp. fermented *iru* and *iru* fermented with *Bacillus* spp. However, no significant difference was observed between the free amino acids of the *Bacillus* spp. fermented *iru* and the one fermented with both species of bacteria.

Organoleptic characteristics: Organoleptic characteristics play an important role in the identification and qualification of African mustard. According to Ouoba *et al*. (2007) each condiment has its own organoleptic characteristics that allow it to be appreciated and distinguished from others. These characters participate in the typicality products that can sometimes be difficult to consume if one is not used to it (Cheynsand Bricas, 2003). These characteristics vary according to the strain and compounds that develop during the fermentation process (N'dir, 2000, Ouoba *et al*., 2003, Parkouda *et al*., 2009 and Ibrahim *et al*., 2011). In order to elucidate the complexity of the sensory modifications observed on the *sumbala* product in general, several studies have been conducted on the substances responsible for the property "flavoring" and / or "flavor modifiers". The study of Beaumont (2002) showed that the high amino acid content of *dawa-dawa*, especially glutamate, contributes to its flavor enhancer effect. Ouoba *et al*. (2005) have also identified in their assays the presence of the aromatic compounds of the pyridines group, the aldehydes and ketones resulting from the metabolism of *Bacillus subtilis* bacteria used as strains. According to Ouoba *et al*. (2005) these compounds are responsible for the flavor of *sumbala*. In addition, Azokpota *et al*. (2008), found in addition to these other aromatic compounds: esters, alcohols, acids, alkanes, alkenes, benzenes, phenols, sulphides and furans in *afitin*, *iru* and *sonru* of Benin. There is also a predominance of aldehydes (3-methylbutanal) and pyrasines (2,5 dimethylpyrasines, tetramethylpyrasines, trimethylpyrasines) in *afitin* and *iru* and reciprocally ketones in *sonru* (Azokpota *et al*., 2008; Amao *et al*., 2018).

Conclusion

It can be concluded that different technological production processes of the African mustard based on *P. biglobosa* almond and *H. sabdariffa* seeds exist, on the other hand to shear light on current state of processing knowledge on these condiments. Traditional technological processes vary from a raw material to another and in concordance with the producers and/or regions. This variability of the process acts directly on the different characteristics, organoleptic, nutritional and microbiological of developed products. In addition, it was found out that sumbala is a potential probiotics condiment with bioactive compounds. Further studies are needed to on this condiment to dipping the knowledge around the heath potential and the technological properties of microbial strains isolated from it. Joint efforts should be made between research laboratories to expand and popularize the data collection to identify all existing variants of this condiment.

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