(Review Article)

Improvement in sausage manufacturing process and potential use of selected aromatic plants as their bio preservatives in Benin

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Publication history: Received on 13 June 2020; revised on 21 June 2020; accepted on 23 June 2020

Article DOI: https://doi.org/10.30574/gscbps.2020.11.3.0180

Abstract

Sausages are among the most common processed meat products worldwide. These products have very high water activity and microbial load, which leads to a short shelf life. To improve their quality and increase their shelf life, the food industry uses several chemicals with harmful consequences on health. Recently, research in essential oils has received increased attention from both industrial and academic circles due to a growing interest in green consumerism and the need for alternative techniques to assure quality and safety of perishable foods. In this review, we have summarized studies dedicated to improving the quality and technology of sausage production. Particular emphasis was placed on essential oils.

Keywords: Sausage; Processing; Natural preservatives; Essential oils; Benin.

1. Introduction

For millennia, man’s main concern was to find and preserve food. It was from the end of the 19th century that the production of cured meats began to industrialize. Nowadays, the production is mainly carried out by specialized industrial companies which reconcile the traditional aspect of cold cuts and the most recent scientific and technological advances. The processing of meats is essentially the result of the concern to obtain from fresh meats, products that can be preserved in order to spread their consumption over time. In addition, the profession, in order to respond to consumer demands, has extended its activity to the production of poultry cold cuts [1]. Sausages are products manufactured from fresh comminuted meats from different meat species, such as pork, beef, chicken, fish and buffalo [2]. Sausages like other cold meats provide the human body with proteins of good biological value, vitamins, minerals, lipids and energy [3].

Their richness in proteins and the nature of these make these products essential foods for a balanced food ration. However, due to their nutritional qualities, sausage and sausage are very favourable environments for contamination [4]. These microbial contaminations can, on the one hand, alter their marketable qualities (taste, smell, appearance, etc.) and, on the other hand, they cause two types of food-borne illness: food poisoning and Infectious diseases [5].

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Toxins are exceptionally heat-resistant proteins: it takes in vitro 3 hours at 100 °C and 10 to 40 minutes at 120 °C to destroy the toxin. They resist digestive enzymes and gastric acidity. The main toxin producing germs are: bacteria (Salmonella, Listeria, Yersinia, Campylobacter, Staphylococci, Clostridium, Jejunii, Escherichia), molds and viruses [6].

The antimicrobial and/or antioxidant preservatives currently employed in these products are chemicals, e.g. sulphur dioxide (SO2), benzoates, sulphites, a-tocopherol, calcium chloride and citric acid as antimicrobial and colour preservative [7] and/or synthetic antioxidants such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and propyl gallate [8] (Kim, Cho, & Han, 2013). However, at short or long-term, these synthetic chemical products could be very toxic, with risks of mutagenicity, chromosomal aberrations and cancer [8, 9, 10], allergic reactions in sulphite hypersensitive consumers. Otherwise, symptoms such as asthma, urticaria, abdominal pains, nausea, diarrhoea, seizures and anaphylactic shock resulting in death have been recorded [2, 8].

Due to the resurgence of the harmful effects of these chemical substances on the human health, the use of essential oils generally recognized as safe (GRAS) as bio preservatives agents of food products could be a credible alternative [11, 12, 13, 2, 14,15, 16, ]. Indeed, essential oils possess antimicrobial activities and are without major effects on the environment and human health [10]. This article aims primarily to summarizing the research results on improvement of sausage processing, current trends in natural preservatives for sausage products and potential use of essential oil as their bio preservative [10].

2. Definition and history of sausages

2.1. Definition

A sausage is a charcuterie product mainly composed of minced meat mixed with other ingredients such as spices and condiments, the preparation is then placed in a gut, of intestinal or synthetic origin, in the form of a tube and closed at the ends. However, there are also meatless vegetarian sausages, made from soya cheese or vegetables for example. The length and the size of the sausage can vary according to the recipes, different cultures in the world being able to manufacture sausages according to their local methods and the tastes of its consumers [17].

2.2. History of sausages

Because sausage manufacturing has been practiced before recorded history, it is not certain how and when the first sausage was produced [18]. To date and to our knowledge, no scientific research published in a serious scientific journal has been interested in the history of sausage production. However, the word “sausage”, however, is derived from saussiche (Old Norman French), salscia (Late Latin) or from salsus (Latin) which means “salted” [19-20]. According to an article published on the site [https://fr.wikipedia.org/wiki/Sausisse#:~:text=Histoire.et%20Cic%C3%A9ren%20dans%20certains%20r%C3%A9sultats%20dans%20certaines%20r%C3%A9sultats] Last accessed on 21/06/2020] and which does not do not cite its sources enough; the sausage would have been born 4,000 or 5,000 years ago. Homer already spoke of it in the Odyssey and Cicero in certain stories. It is likely that it was invented with a view to preserving or facilitating the transport of meat, as was its use in Antiquity, or simply from a principle of economy among butchers. Some Roman legions used the sausage principle to transport pre-divided meat. Often the envelope was thrown away and only the inside was kept, in order to prepare the famous “legionary rations” which then included the equivalent of one sausage per meal. It should be noted that the sausage in Rome was introduced from the ancient city of Lucania. From this import came the export to certain places like North Africa where Gaul adopted it and used it according to the same principle. A Roman festival also existed for the sausage; Lupercales were celebrated by eating sausage at the time.

It is certain that at the same time the Chinese often used a principle similar to the European sausage, using goat and lamb meat. In the Middle Ages, quality sausage was produced, to which spices and spices were added, which were brought in from the East at great cost by the famous silk route. It is reported among other things that in the Byzantine Empire blood sausage was, for a time, prohibited, because of a problem of food poisoning, frequent at the time. An Anglo-Saxon tradition dating from the Second World War means that the majority of sausages have a high level of starchy foods, up to 25%, in order to compensate for the lack of meat of the time. The remaining practice is mainly used during cooking: while the meat contracts when cooked, the starchy food (flour, starch, etc.) expands by absorbing water and part of the fat, thus making it possible to do not distort the sausage. Although the process has been known since the Middle Ages (and used among others in Germany), it is from this event that modern tradition comes to us, because some industrial production of cheap foodstuffs could be established at that time.
Since the end of the 20th century, the sausage is often seen far from fine cuisine, although there is always a certain refinement in the world of sausage, but also because the majority of sausages have very high fat and salt levels. Today the sausage is often perceived as a recovery of edible meat waste, known as mechanically separated meat, filled with chemical preservatives [19].

3. Sausage classification

According to Rust [21] sausage production began with a simple process of salting and drying the meats which helped improve the shelf life of the sausages. Subsequently, aromas and spices were incorporated to improve the organoleptic quality of the product. The product was then stuffed in a container, namely the gastrointestinal tract of animals, to make the product more convenient to eat.

The manufacturing process may vary because seasoned meat is minced, stuffed in casings, and can be smoked, dried, fermented and heated. There is a large variety of sausages and the different variants are linked to the modification of the type of meat, the processing temperature, types of casings and the particle size of the casings [2, 18]. Table 1 shows the different types of sausages.

Table 1 Sausage classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>Characteristics</th>
<th>Examples</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw sausages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td>Made from fresh comminuted, uncured, non-smoked meats. Must be refrigerated prior to heating by the consumer.</td>
<td>Breakfast sausage (USA), boerewors (South Africa), bratwurst (Germany), merguez (North Africa), siskonmakkara (Finland)</td>
<td>[2, 18, 22]</td>
</tr>
<tr>
<td>Fermented</td>
<td>Made from comminuted, cured or uncured, fermented and often smoked meats. Not heat-processed.</td>
<td></td>
<td>[2, 18]</td>
</tr>
<tr>
<td>Semidry (quickly fermented)</td>
<td>Stuffed in medium- and large-diameter artificial casings. &quot;Tangy&quot; flavour produced by fermentation. Length of smoking and fermentation depends on type but rarely exceeds a few days. Improved stability of stored refrigerated.</td>
<td>Variety of summer sausages, cervelats, mettwursts, Lebanon bologna (USA)</td>
<td>[2, 18, 23]</td>
</tr>
<tr>
<td>Dry (slowly fermented)</td>
<td></td>
<td>Different types of salamis, droë wors (South Africa, not fermented)</td>
<td>[2, 18, 24]</td>
</tr>
<tr>
<td>Heat-processed sausages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoked precooked</td>
<td>Mostly comminuted, cured, non-fermented. Final cooking before consumption</td>
<td>Chinese pork sausages, kielbasa</td>
<td>[2, 18, 25]</td>
</tr>
<tr>
<td>Emulsion-type</td>
<td>Made from comminuted well-homogenized cured meats, fat, water and seasoning. Usually smoked, slightly cooked. Ready-to-eat product.</td>
<td>Frankfurters, wiener, bologna, mortadella</td>
<td>[2, 18, 26]</td>
</tr>
<tr>
<td>Cooked</td>
<td>Made from previously comminuted cooked fresh or cured raw materials. Final cooking after stuffing. With or without smoking. Ready-to-eat product.</td>
<td>Liver sausage, Braunschweiger</td>
<td>[2, 18]</td>
</tr>
</tbody>
</table>
4. Manufacturing process of sausage and its improvement

4.1. Manufacturing process of sausage

In their study entitled Preparation of sausage from spent duck—an acceptability study, Bhattacharyya et al [27] have produced three types of sausages namely: viz. sausage from broiler, spent hen and spent duck meat. After adequate thawing, the meat was weighed, cut into small chunks and minced in a meat mincer (10 mm plate). Recipe for preparation of 1 kg sausage batter included: minced meat 600 g, vegetable fat 200 g, ice flakes 100 g, salt 25 g, sugar 10 g, monosodium glutamate 0.5 g, sodium nitrate and sodium nitrite 0.1 g each, condiments 45 g, spice mix 15 g and wheat flour 34.3 g. Sausage emulsion was prepared in a bowl chopper. The emulsion was stuffed into natural and artificial casings separately, using mechanical sausage-filler and linked manually and were kept at air-conditioned temperature (15–18 °C) for 4 h for uniform setting. These were smoked for 8 h in a smokehouse at a temperature of 68–70 °C and then steam-cooked to a core temperature of 85 °C followed by cold showering for 10 min.

In Benin, industrial production of sausage is almost non-existent. However, the growing consumption of sausages in the country is prompting their import in large quantities. Unfortunately, the quality of these products is not always guaranteed. To alleviate this problem, VETAGRO SA invested in the production of cooked chicken sausage called Mori’fresh. The process used by this company incorporates several stages namely: reception, boning, preparation of melee, embossing, cooking, conditioning, sterilization, labelling and packaging.

4.1.1. Reception

Broilers having undergone regular veterinary care are slaughtered at a weight greater than or equal to 2 kg. For this purpose, knives, bleeders and the feathers are used. The carcasses are kept in the cold room.

4.1.2. Boning

Boning involves extracting bones and cartilage. It is practiced using knives on a teflon cutting surface.

4.1.3. Preparation of scrums

The quantities of lean and fatty meats are weighed and then minced (cut the meats into small pieces) and mixed in the cutter with the ingredients, additives and colouring previously weighed. Temperature controls are made during this step in order to avoid temperature increases dangerous for the quality of the product: once the emulsion is obtained, the face is sent to the pusher for embossing.

4.1.4. Embossing

This step consists in putting the scrums in a hose to give it its characteristic shape. The pusher has a portioner which allows the scrums to be pushed in portions into the casings. Once pushed the sausages are placed in the drying cabinet at an air-conditioned temperature (15 – 18 °C) for 2 hours to take shape and then sent to the cooker.

4.1.5. Cooking

In these rooms with a digested atmosphere, the product is heated so that the internal microorganisms act in order to stabilize. Cooking is done for 30 minutes at 72 °C at heart. Once this step is completed, the sausages are put in the cooling plunger (water + ice) to stop cooking.

4.1.6. Conditioning

Cooked sausages are put in bags of ten (10) units. Then put in the wrapper which allows to expel the vacuum and to seal the bag.

4.1.7. Sterilization

The packaged sausages are placed in the sterilizer at 100 °C for 5 minutes.

4.1.8. Labeling and cardboarding

Sterilized products are labeled and cardboarded with thirty (30) bags. The cartons are stored in the cold room (-18°C).
4.2. Improvement of manufacturing process of sausage

Several studies have investigated the use of natural products as bio conservatives for sausages. The efficacy of nisin at three different concentrations, 12.5, 25 and 50 ppm, on the keeping quality of fish sausage in synthetic casing at ambient (28 ± 2 °C) and refrigerated (6 ± 2 °C) temperatures was assessed. Result showed that fish sausage treated with 50 ppm of nisin was acceptable after storage at ambient temperature for 20–22 days compared with the control, which were acceptable only for 2 days [28]. The effect of lacticin 3147 and nisin on the shelf life of fresh pork sausage and their ability to control pathogens as *Clostridium perfringens* DSM 756, *Salmonella kentucky* AT1 and nonpathogenic as *Listeria innocua* DPC 1770. There was no significant difference in the activity of nisin and lacticin 3147 against any of the target strains used, both bacteriocins performing significantly better than sodium metabisulfite against gram-positive strains in broth systems [29].

Other authors have suggested the use of starters to improve the fermentation process. For example, Hüfner et al [30] demonstrated that the performance of *Lactobacillus sakei* in sausage fermentation can be improved by preinoculation treatments with sub lethal heat, cold, and salt stress. In addition, the instrumental and sensory analyzes carried out by Jridi et al [31] showed that the reduction in the salt content did not depreciate the quality and acceptability of the sausages. Furthermore, the sensory evaluation demonstrated that the products made from purebred Al pigs have the highest overall appreciation values. Microbial and animal-derived natural compounds were investigated for their antimicrobial and antioxidant in fresh sausages. Table 2 summarizes the main innovations in the manufacturing process of sausage.

**Table 2** Summary of the main suggested improvements in sausage processing

<table>
<thead>
<tr>
<th>Types of sausage investigated</th>
<th>Suggested improvement</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish sausage</td>
<td>Use of nisin as a preservative</td>
<td>[28]</td>
</tr>
<tr>
<td>Pork Sausage</td>
<td>Use of Lacticin as Biopreservative</td>
<td>[29]</td>
</tr>
<tr>
<td>Raw Sausage</td>
<td>Improvement of Fermentation by Stress-Conditioning of the Starter Organism <em>Lactobacillus sakei</em></td>
<td>[30]</td>
</tr>
<tr>
<td>Meat sausage</td>
<td>Improvement of the physicochemical, textural and sensory sausage properties by edible cuttlefish gelatin addition</td>
<td>[31]</td>
</tr>
<tr>
<td>Fresh Sausage</td>
<td>Shelf-life extension and improvement of the Microbiological Quality by Irradiation</td>
<td>[32]</td>
</tr>
<tr>
<td>Pork Sausage</td>
<td>Storage Properties Improvement and Reducing of Sodium Nitrate by <em>Glycyrrhiza uralensis</em> and <em>Curcula longa</em></td>
<td>[33]</td>
</tr>
<tr>
<td>Chicken Sausage</td>
<td>Use of Monoxide Hemoglobin in sausage color improvement</td>
<td>[35]</td>
</tr>
<tr>
<td>Model sausage</td>
<td>Use of chicken sarcoplasmic proteins for rheological improvement</td>
<td>[36]</td>
</tr>
<tr>
<td>Fermented Sausage</td>
<td>Antioxidant Activities of Lactic Acid Bacteria for Quality Improvement</td>
<td>[37]</td>
</tr>
<tr>
<td>Traditional sausages</td>
<td>Demonstration of the acute toxicity of the dye (Rhodamine B) used in the manufacture</td>
<td>[38]</td>
</tr>
</tbody>
</table>

--: Unspecified

5. Essential oils

5.1. Definition and localization

Essential oil is a product obtained from a vegetable raw material, either by steam entrainment, or by mechanical processes from the Citrus epicarp or by dry distillation, and which is separated from the aqueous phase by physical processes [39].
Essential oils are produced in specialized glandular cells covered with a cuticle. They are then stored in cells with essential oils (Lauraceae or Zingiberaceae), in secretory hairs (Lamiaceae), in secretory bags (Myrtaceae or Rutaceae) or in secretory channels (Apiaceae or Asteraceae). They can also be transported into the intracellular space when the gasoline pockets are located in the internal tissues [40]. They are located either in the flowers (ylang-ylang, bergamot, rose), or in the flowering tops (marigold, lavender), or in the leaves (lemongrass, eucalyptus), or in the bark (cinnamon), or in roots (vetiver), or in fruits (vanilla), or in seeds (nutmeg) or elsewhere in the plant [41].

5.2. Essential oils and food

There are several reasons for using essential oils to improve the quality and preservation of food. These plant extracts, reservoirs of natural antioxidants, contain molecules with interesting biological activities and have no major effects on the environment and human health [42, 43, 44]. Néguefack et al. [45] reported the fungicidal effect of the essential oils of *Cymbopogon citratus* on the toxinogenic molds found in certain foods. More recently, other authors have reported the effectiveness of plant extracts for the conservation of tomatoes [46], Peuhl “waragashi” cheese [47], peanuts [48], fish [49], margarine [50] and meat [51], local beer *tchakpalo* [52] and *lanhouin*-based cube broth [53].

5.3. Mechanisms of antimicrobial action of essential oils

The antimicrobial mechanisms of plant extracts action have been widely relayed by several publications. Essential oils kill the fungal cell via binding primarily to ergosterol, the major sterol found in fungal cellular membrane. This binding destroys the osmotic integrity of the membrane, and this is followed by leakage of intracellular potassium, magnesium, sugars, and metabolites and finally by cellular death. Lipid characteristics of essential oils act via the same mechanism. It has been suggested that oxidative damage due to essential oil may also contribute to its antifungal activity against *Candida* [42, 45].

![Figure 1](image1.png)

*Figure 1* Locations and mechanisms in the bacterial cell thought to be sites of action for essential oils components [42].

Considering the large number of different groups of chemical compounds present in essential oils, it is most likely that their antibacterial activity is not attributable to one specific mechanism but that there are several targets in the cell. An important characteristic of essential oils and their components is their hydrophobicity, which enables them to partition in the lipids of the bacterial cell membrane and mitochondria, disturbing the structures and rendering them more permeable. Leakage of ions and other cell contents can then occur [42, 54]. Figure 1 presented the locations in the bacterial cell thought to be sites of action for essential oils components. Major effects are: degradation of the cell wall, damage to cytoplasmic membrane, damage to membrane proteins, leakage of cell contents, coagulation of cytoplasm and depletion of the proton motive force [42, 54, 55].

Otherwise the use of volatile plant extracts to improve the quality of various forms of sausage has been proposed by several studies (table 3).
Table 3 Effectiveness of essential oils in sausages

<table>
<thead>
<tr>
<th>Essential oils from</th>
<th>Highlighted potentials</th>
<th>Key findings</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myristica fragrans</td>
<td>Oxidative and Microbial stability</td>
<td>Addition of nutmeg essential oil influenced the slower lipid oxidation and growth of total aerobic mesophilic bacteria, as well as improvement of aroma of cooked sausages during long storage period (60 days)</td>
<td>[56]</td>
</tr>
<tr>
<td>Juniperus communis L.</td>
<td>Antioxidant Activity</td>
<td>Essential oil, used in a concentration of 0.01 μl/g (JO1), retarded radical formation and reduced the growth of total aerobic mesophilic bacteria and improved the colour of cooked sausages, with slight to moderate alteration of the original flavour of cooked sausages.</td>
<td>[57]</td>
</tr>
<tr>
<td>Origanum vulgare</td>
<td>Antifungal activity, influence on Microbial and Physicochemical Characteristics</td>
<td>Presence of some molds on the surface of fermented sausages can be reduced by the use of OEO without causing considerable modifications to the physicochemical and microbiological properties of the sausages.</td>
<td>[58]</td>
</tr>
<tr>
<td>Origanum majorana L.</td>
<td>Antimicrobial activity</td>
<td>Addition of essential oil to fresh sausage exerted a bacteriostatic effect at oil concentrations lower than the MIC, while a bactericidal effect was observed at higher oil concentrations which also caused alterations in the taste of the product.</td>
<td>[59]</td>
</tr>
<tr>
<td>Satureja montana L.</td>
<td>Antioxidant effects</td>
<td>The use of savory essential oils in high concentrations with high levels of sodium nitrite can promote undesirable sensory changes by changing the characteristic color of the product. The antioxidant activity and effect of essential oils on lipid oxidation in mortadella was confirmed by reduced oxidative reactions.</td>
<td>[60]</td>
</tr>
<tr>
<td>Laurus nobilis</td>
<td>Antibacterial activity</td>
<td>Application of essential oils in fresh sausages at the concentrations of 0.05 and 0.1 g/100 g might provide additional protection of this product against microbial growth, thereby increasing its shelf life.</td>
<td>[61]</td>
</tr>
<tr>
<td>Ocimum basilicum L.</td>
<td>Antibacterial activity</td>
<td>Basil essential oil presented antibacterial activity in all tested bacteria, with the exception of Pseudomonas aeruginosa.</td>
<td>[62]</td>
</tr>
<tr>
<td>Mentha piperita</td>
<td>Functional property</td>
<td>Replacement of 50 % of nitrite with essential oils is a reasonable approach in order to put down harmful effects of nitrite in sausage and to enhance functionality of the product.</td>
<td>[63]</td>
</tr>
<tr>
<td>Citrus waste water, thyme and oregano essential</td>
<td></td>
<td>Addition of essential oil to cooked meat products is a viable alternative for increasing the oxidative stability of the samples, while reducing nitrite levels.</td>
<td>[64]</td>
</tr>
</tbody>
</table>

6. Legislation

A certain number of molecules making up essential oils have been registered by the European Commission for their use as flavorings in foodstuffs. Registered flavors are considered to pose no risk to the health of the consumer and include, among others, carvacrol, carvone, cinnamaldehyde, citral, p-cymene, eugenol, limonene, menthol and thymol [42, 65]. Estragole and methyl eugenol were removed from the list in 2001 due to their side effects. The United States, through the United States Food and Drug Administration (USFDA) has classified these substances as Generally Recognized as Safe Food Additives (GRAS). However, Astragola, expressly prohibited as a flavoring in the European Union, is authorized on the USFDA list [42].

New flavors can only be registered after toxicological and metabolic studies according to the Regulatory Commission (EC) n° 622/2002, which could involve a considerable financial effort. If these molecules are added to food for purposes other than flavoring, these molecules can be considered as new food additives. Thus, obtaining approval as a safe food additive would involve significant metabolic and toxicological studies, the cost of which can be prohibitive. Therefore,
it would be interesting, especially for developing countries, to use a spice or an essential oil as a food ingredient, than to use molecules which will require prior authorizations (Smid and Gorris, 1999).

7. Conclusion

In order to improve sausage production technology and limit the use of chemicals, several alternatives have been proposed in the literature. In review, we highlighted most of these innovations. Regarding the improvement in processing, the use of nisin, actin as biopreservative, use of starter to improve fermentation, physicochemical, textural and sensory properties of sausage, shelf-life extension by irradiation, storage properties improvement and reducing of Sodium Nitrate by Glycyrrhiza uralensis and Curcula longa... have been suggested. In addition, plant extracts are used for their antioxidant, antimicrobial and functional properties.

Compliance with ethical standards

Acknowledgments

The authors thank VETAGRO SA for their financial support.

Disclosure of conflict of interest

The authors agree no conflict of interest.

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How to cite this article