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Major component and potential applications of plant essentials oils as natural food preservatives: a short review research results

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Abstract

The present review takes in account studies relative to the potential applications as natural food preservatives and major components of essential oils extracted from some aromatic edible herbs and spices *Allium sativum, Cinnamomum zeylanicum, Cympobopon citratus, Mentha piperita, Pimenta racemosa, Ocimum gratissimum, Syzygium aromaticum, Xylopia aethiopica* and *Zingiber officinale*. Therefore, some informations relative to antibacterial and antifungal efficiency of these essential oils on either foods pathogens responsible for humans foodborne diseases and foods deterioration and its poor quality (bacteria: *Escherichia coli*, *Salmonella*, *Listeria monocytogenes*, *Staphylococcus aureus;* more pathogen yeast *Candida albicans* and moulds: *Aspergillus, Fusarium and Penicillium*) are presented. Furthermore, this short review doesn't occult its main highest elevation which is the presentation of main components and interesting potential applications as food preservatives of these essentials oils. Their application as natural preservatives of traditional cheese Wagashi product in Benin will be tested.

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Introduction

Food safety is a fundamental concern of both consumers and the food industry especially as the number of reported cases of food-associated infections continues to increase. Notified cases of foodborne illness in England and Wales now exceed 100 000 a year, this represents only a fraction of the true incidence due to a substantial degree of underreporting (Smith Palmer *et al.,* 2001). Also, it has been estimated that as many as 30% of people in industrialized countries suffer from a food borne disease each year and in 2000 at least two million people died from diarrhoeal disease worldwide (WHO, 2002). Microbial activity is a primary mode of deterioration of foods and many microorganisms are associated with these affections after contributed for the loss of food quality and safety. Antimicrobial chemicals had been largely used as foods preservatives, but unfortunately the uncontrolled concentrations applied increase the risk of toxic residues in the products (Tatsadjieu *et al.,* 2009; Yèhouenou et al., 2010a). Due to the increasing of the negative effects of these chemical synthetic products on human and animal health, the importance of alternative natural products to control foods pathogenic microorganisms is urgently needed (Bankolé, 1997; Burt, 2004; Bajpai *et al.,* 2011). Essential oils (EOs) as antimicrobial agents are recognized as safe natural substances to their user and for the environment and they have been considered at low risk for resistance development by pathogenic microorganisms (Tatsadjieu *et al.,* 2003; Antunes and Cavaco, 2010). The use of essential oils as biopreservatives becomes a matter of great interest for all especially for the food industry since consumers prefer natural additives instead of synthetic ones. That is why many studies have been performed on this subject in the last few years (Lang and Buchbauer, 2012). In fact, many authors such as Asekun and Adeniyi (2004), Burt (2004), Oussou *et al.* (2004), Sasidharan and Menon (2010), Yèhouenou *et al.* (2010a, 2010b), Styczynska, (2011), Noudogbessi *et al.* (2011), Ogundajo *et al.* (2011), Nguefack *et al.* (2004, 2009, 2012) and others have studied for ones the chemical composition of essential oils from plants and for others the antimicrobial activities and potential biopreservation applications, insecticidal activity, antimycotic activity and antioxidant activity of these EO. It will be better to regroup these informations according to focus.

This paper aims primarily to summarizing the research results on the main components and food preservatives uses of essential oils extracted from edibles herbs and spices *Allium sativum, Cinnamomum zeylanicum, Cympobopon citratus, Mentha piperita, Pimenta racemosa, Ocimum gratissimum, Syzygium aromaticum, Xylopia aethiopica* and *Zingiber officinale*. Indeed, these spices and herbs are at first sight largely distributed or commercialized in the world, consumed by the populations and used in traditional medicine against pains such as dyspepsia, malaria, diabetes, urinary tract infections and respiratory diseases, cough, fever, diarrhea, abdominal pain, conjunctivitis, mouth sores and dental infections, stomachaches, bronchitis, liver disease and dysentery for *Ocimum gratissimum, Mentha piperita, Xylopia aethiopica, Eugenia caryophyllata, Pimenta racemosa, Cinnamomum zeylanicum* (Chami *et al.,* 2005; Betoni *et al.,* 2006; Nwinyi *et al.,* 2009; Yehouenou *et al.,* 2010b). *Ocimum* species is used against cancer, cardiovascular disease, HIV1 infections (Tomar *et al.,* 2010; Akujobi *et al.,* 2010); treatment of nervous and gastrointestinal disorders. *Cymbopogon citratus* is used against hypertension (Madingou *et al.,* 2012). Informations relative to the major components of EOs which provide them potential antimicrobic effects and their capacity of food biopreserving studied by many researchers deserve to be gathered as data base in order to promote further researches in the sector of food biopreserving.

Essential oils extraction and chemical analysis

Essential oils are products, generally, of rather complex composition comprising the volatile principles contained in the plants, and more or less modified during the preparation process. They are essentially obtained by hydrodistillation where the plant material is heated in two to three times its weight of water with indirect steam from outside the still. Chemical analysis of essential oils is generally using GC (quantitative analysis) and GC/MS (qualitative analysis). Identification of the main components is carried out by the comparison of both the GC retention times and MS data against those of the reference standards (with known source) (Lahlou, 2004).

Mechanism of antimicrobial action of essential oils

Antifungal action: Antifungal agents such as 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 (Medoff, 1988; Murray et al., 2003). 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* (Murray *et al.,* 2003).

Antibacterial actions: Considering the large number of different groups of chemical compounds present in EOs, 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 EOs 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 and causes the death of bacterial cell (Burt, 2004; Yehouenou *et al.,* 2010b). Generally, the EOs possessing the strongest antibacterial properties against food borne pathogens contain a high percentage of phenolic compounds such as carvacrol, eugenol and thymol (Burt, 2004).

Major components of essential oils

The major component of clove oil is eugenol, a phenolic compound but the proportions vary widely. For example, Raina *et al.* (2001) found in essential oil of *Eugenia caryophyllata* a high percentage of eugenol (94.41%) with 2% β-caryophyllene whereas Prashar et al. (2006) found the content of eugenol to be 78%, with 13% β-caryophyllene. Pawar and Thaker (2006) found that the content of eugenol was 47.64%, with the concentration of benzyl alcohol at 34.10%. Chaeib *et al.* (2007) obtained a high concentration of eugenol (88.58%), eugenyl acetate (5.62%) in essential oil of *Syzygium aromaticum* which contained 79.2% and 85% eugenol (Ranasinghe *et al.,* 2002; Pinto *et al.,* 2009). Essential oil of cinnamon contains high concentration (62.79-65%) of trans-cinnamaldehyde with 8.31% limonene and 7.09% eugenol (Ranasinghe *et al.,* 2002; Simic *et al.,* 2004; Burt, 2004).

Cinnamon essential oil reported by Kamaliroosta et al. (2012) for Tehran specimen contained cinnamic aldehyde (62.09%) as major components whereas data provided by Schmidt *et al.* (2006) on *Cinnamomum zeylanicum* from Sri Lanka where eugenol 74.9%, followed by caryophyllene 4.1%, benzyl benzoate are major components. (E)-cinnamaldehyde (68.95%) was the major component identified from *C. zeylanicum* bark essential oil of Turkey by Unlu et al. (2010) while benzyl benzoate (74.8%) was the main component of cinnamon leaf essential oil from Nigeria (Tira-Picos *et al.,* 2009).

Sahouo *et al.* (2003) found that the predominant components of essential oil of *Ocimum gratissimum* in Ivory Coast were thymol (70.8%). Oussou et al. (2004) identified the chemotype thymol-p-cymene as essential oil of *Ocimum gratissimum* in Ivory Coast. Aquinos Lemos *et al.* (2005) isolated from similar oil in Brazil eugenol (57.82%) and (Z)-α-bisabolene (17.7%) *as* major components. Madeira *et al.* (2005) underlined in their studies that essential oil of *Ocimum gratissimum* was in majority composed of 1-8 cineole (39.3%) and eugenol (35.5%). Matasyoh (2007) found eugenol (68.81%)

and methyl-eugenol (13.21%) as main components in Kenya. Oussou et al. (2010) identified in this oil thymol (34.6%). Saliu et al. (2011) reported that main components of *Ocimum gratissimum* EOs in Nigeria were eugenol (61.9%) and cis-ocimene (8.2%).

The main constituents identified in *Allium sativum* essential oil were diallyltrisulfide, diallylsulfide, allylmethyltrisulfide (Styczynska, 2011). In the ginger oil, 26 constituents were identified, with 1,8-cineole (10.9%), neral (8.1%), geraniol (14.5%), geranial (9.5%) as major components (Gupta *et al.,* 2011). Major components were zingiberene (23.9%), β-bisabolene (11.4%) and β-sesquiphellandrene (10.9%) according to sacchetti *et al.* (2005). The chemical compositions of fresh ginger oil and dry ginger oil revealed that zingiberene (28.6-30.3%) was the major components, followed respectively by geranial (8.5%) and arcurcumene (Sasidharan and Menon, 2010).

Essential oil of *Mentha piperita* is in majority composed of menthol (28.3-60%) menthone (15-32%) (Bassolé *et al.,* 2010; Styczynska, 2011). It's chemotype in Benin is menthol-neomenthol (Dahouenon-Ahoussi et al., 2010).

The main components of essential oil of *Pimenta racemosa* investigated by Noudogbessi *et al.* (2008) in Benin were eugenol (61,9 %-55,7%); chavicol (15,3%-8,0%) et le myrcène (22,3%-12,5%) similar to those identified in the same plant by Jirovetz et al. (2007) and Höferl *et al.* (2009). In contrary, Ogundajo et al (2011) identified germacrene-D and β-elemene in bay essential oil.

Cymbopogon citratus essential oil is composed in majority of citral (neral + geranial) (Paranagama *et al.,* 2003; Burt, 2004; Nguefack *et al.,* 2004, 2009, 2012). The composition of the oil of *Xylopia aethiopica* is very diverse. The main components of the essential oil of *Xylopia aethiopica* fruit from Benin are: sabinene (9.8-41.8%), terpinen-4-ol (9.2-30.8%) (Noudogbessi *et al.,* 2011). Similar oil from Ghana showed thirty nine compounds among which germacrene D was the highest (25.1%) in addition to β-pinene (21.6%) (Karioti et al., 2004). Essential oil of *Xylopia aethiopica* fruit from Nigeria studied by Olonisakin et al. (2007) revealed that predominant components are β-pinene (13.78%) and β-phellandrene (12.36%). Noudjou *et al.* (2007) identified sixty three components in essential oil of *Xylopia aethiopica* from Cameroon. The main constituents were β-phellandrene+1,8-cineole (31.0%). Keita *et al.* (2003) detected thirty constituents in essential oil of *Xylopia aethiopica* fruit from Mali. The main constituents identified in the EOs were β-pinene (19.1%), γ-terpinene (14.7%). Tatsadjieu et al. (2003) identified in the fruits of *X. aethiopica* the presence of b-pinene (18,3%), terpinen-4-ol (8,9%), sabinene (7,2%), a-phellandrene (7,1%).

Antimicrobial activity of essential oils

The antibacterial activity of different *Eugenia caryophyllata* extracts has been demonstrated against pathogenic bacteria including *Campylobacter jejuni, Salmonella enteritidis, Escherichia coli and Staphylococcus aureus*, *Pseudomonas aeruginosa, Klebsiella pneumoniae, Listeria monocytogenes, Bacillus cereus* (Friedman et al., 2002; Burt and Reinders, 2003; Burt, 2004; Unlu et al., 2010). A recent study reported that the growth rates of *Listeria monocytogenes* strains observed at 15 °C and at 5 °C were significantly reduced by treatment with 1% and 2% clove oil (Mytle *et al.,* 2006) and furthermore, Ogunwande *et al.* (2005) found that the essential oil of the fruit exhibited strong antibacterial activity against *Staphylococcus aureus*, while the leaf oil strongly inhibited the growth of *Bacillus cereus*. The fungicidal activity of *Eugenia caryophyllata* essential oil has also been reported on several food-borne fungal species (Lopez *et al.,* 2005) and it was observed in a recent study that the essential oil of clove even inhibited the growth of *Aspergillus niger* (Pawar and Thaker, 2006). Studies of Pinto *et al.* (2009) showed that essential oil of *Syzygium aromaticum* is effective against some species of

Aspergilli (*Aspergillus flavus, A. fumigatus), Candida* and dermatophytes species such as *Microsporum canis.*

Table 1. Major components, susceptible microorganisms and food preserved of selective essential oils.

Common name of - plant	Latin name of plant source	Major components	Approximate % composition	EO active against	Potential biopreservative of	References
Garlic or dehydrated garlic	*Allium sativum*	Diallyltrisulfide Diallylsulfide Allylmethyltrisulfide	49.2% 37.0% 5.6%	*Aspergillus fumigatus, A. niger, S. aureus, Salmonella enteritidis, Penicillium cyclopium, Fusarium oxysporum*	-	Benkeblia (2004), Bansod and Rai (2008), Styczynska (2011).
Cinnamon	*Cinnamomum zeylanicum*	Trans-cinnamaldehyde Limonene Eugenol	62.79-65% 8.31% 7.09-76.9	*Aspergillus niger, A. ochraceus, A. versicolor, A. flavus, A. terreus, Penicillium ochrochloron, Fusarium proliferatum*	Banana, vegetable, dairy products	Ranasinghe et al. (2002) ; Burt (2004), Simic et al. (2004), Tira-Picos et al. (2009), Xing et al. (2010), Kamaliroosta et al. (2012), Schmidt et al. (2006)
Lemongrass	*Cymbopogon citratus*	E-Citral/Geranial Z-Citral/Neral	37.7 21.2-80	*Penicillium expansum, P. verrucosum, A. ochraceus, A. flavus, L. monocytogenes, Salmonella*	fruits and vegetables, rice	Burt (2004); Nguefack et al. (2009), Nguefack et al. (2004), Nguefack et al. (2012).
Peppermint tea	*Mentha piperita*	menthol menthone neomenthol	28.0-46.7%, 25.2-32% 8.26%,	*Salmonella enteritidis, E. coli, Streptococcus faecalis ; L. monocytogenes Staphylococcus epidermidis, A. fumigatus,*	Africa drink, dairy products; fish dishes; vegetables	Burt (2004), Bassolé et al. (2010), Dahouenon-Ahoussi et al. (2010), Styczynska (2010).
Clove basil or African basil/wild basil	*Ocimum gratissimum*	Thymol p-Cymene γ-terpinène eugenol methyl eugenol cis-ocimene	19.7- 70.8% 23.5-25% 37.4% 53.89-68.8% 13.21% 23.97%	*Penicillium expansum, P. verrucosum, Aspergillus ochraceus, S. aureus, E. coli, P.*	fruits and vegetables	Nguefack et al. (2004), Matasyoh et al. (2007), Nguefack et al. (2009), Oussou et al. (2010), Saliu et al. (2011),

				aeruginosae, Salmonella typhi, C. albicans, Listeria monocytogenes,		Nguefack et al. (2012)
Bay	*Pimenta racemosa*	eugenol chavicol myrcene Germacrene D	61,9 %-55,7% 15,3%-8,0% 22,3%-12,5% 10.6%	*E. coli, Pseudomonas aeruginosa, C. albicans, Aspergillus niger, P. verrocosum*	Potatoes	Jirovetz et al. (2007) and Höferl et al. (2009), Ogundajo et al. (2011),
Clove (bud)	*Syzygium aromaticum*	Eugenol Eugenyl acetate	47.64 -94.41 % 8 - 15 %	*Listeria monocytogenes, B. cereus, Campylobacter jejuni, Salmonella enteritidis, Aspergillus niger, A. flavus, A. fumigatus, C. albicans, Fusarium. proliferatum, Pseudomonas aeruginosa,*	chicken frankfurters, banana, minced mutton, dairy products	Ranasinghe et al. (2002), Burt (2004), Mytle et al. (2006), Prashar et al. (2006), Pinto et al. (2009), Unlu et al. (2010).
African pepper, Ethiopian Pepper,	*Xylopia aethiopica**	a-sabinene, terpinen-4-ol germacrene D phellandrene	9.8-41,8% 9.2- 30,8% 25% 12.36%	*Listeria monocytogenes, Salmonella enteritidis, S. aureus Bacillus subtilis, Pseudomonas E. coli, Aspergillus flavus,*	*Sitophilus zeamais*	. Noudjou et al. (2007), Yehouenou et al. (2010a) ; Noudogbessi et al. (2011)
Ginger	*Zingiber officinale*	1,8-cineole neral geraniol geranial zingiberene	10.9% 8.1% 14.5% 9.5% 13.97-23.9%	*Bacillus subtilis, Pseudomonas aeruginosa, Aspergillus niger, A. fumigatus, Pencillium* spp. *Saccharomyces cerevisiae, Fusarium moniliforme*	Beverage, soft drink, types of medicinal substances	Sacchetti et al. (2005), Singh et al. (2008), Sasidharan and Menon (2010). Gupta et al. (2011)

Many studies have assessed the antibacterial activity of peppermint (Furuhata *et al.,* 2000; Inouye *et al.,* 2001; Iscan *et al.,* 2002; Azuma *et al.,* 2003) and antifungal (Blaszczyk *et al.,* 2000; Edris and Farrag, 2003; Mimica-Dukic *et al.,* 2003; Mckay and Blumberg, 2006). For example, mint (*Mentha piperita*) EO was more effective against *Staphylococcus aureus* and *Salmonella enteritidis* (Tassou *et al.,* 2000). Inouye *et al.* (2001) reported the major respiratory tract pathogens, including *Haemophilus influenza, Streptococcus pneumonia, S. pyogens, Staphylococcus aureus* were susceptible to peppermint oil and its components menthol and menthone. Another respiratory tract pathogens, *Legionella pneumophila*, was also found to be susceptible to peppermint (Furuhata *et al.,* 2000). In other study mint oil was effective against *Salmonella enteritidis* compared to *Listeria monocytogenes* (Burt, 2004). Iscan *et al.* (2002) tested peppermint oil and its components menthol and menthone against 21 human and plant pathogens and found moderate inhibitory activity against the human pathogens. The oil showed stronger inhibition against *Pseudomonas* and *Xanthomonas* strains of plant pathogens. Mimica-Dukic *et al.* (2003) reported that *Mentha piperita* essential oil was more effective against a multiresistant strain of *Shigella sonei* and *Micrococcus flavus* than oils from other *Mentha* species. The fungicidal activity of peppermint oil was demonstrated in 11 of 12 fungi tested by Pattnaik *et al.* (1996) including *Candida albicans, Trichophyton mentagrophytes, Aspergillus fumigatus* and *Cryptococcus neoformans* (McKay and Blumberg, 2006).

According to Simic *et al.* (2004), essential oil of cinnamon is more effective against filamentous fungi such as *Aspergillus niger, A. ochraceus, A. flavus, A. terreus, Penicillium versicolor, Fusarium sporotrichoides*. It was reported that Cinnamomum zeylanicum essential oil is active against the postharvest pathogens such as *Rhizopus nigricans, Aspergillus flavus* and *Penicillium expansum*, the causal agents of jujube or orange fruit (Xing et al., 2010).

Aurore *et al.* (1998) and Ogundajo *et al.* (2011) reported that essential oil of *Pimenta racemosa* was effective against *Staphylococcus aureus, Enterococcus faecium, E. coli, Pseudomonas aeruginosa* et *Mycobacterium smegmatis*) and fungi (*Candida albicans, Aspergillus niger, Absidia corymbifera and Penicillium verrocosum.*

Asekun and Adeniyi (2004) reported that *Xylopia aethiopica* essential oil from Nigeria inhibited growth of four groups of fungi (*Stellocapella madis, Candida albicans, Aspergillus flavus, A. ochraceus* and *Fusarium oxysporum*). Similar oil from Cameroon inhibited the growth of eight strains of micro-organisms, *E. coli, S. aureus, Klebsiella pneumoniae, Enterococcus faecalis, Corynebacterium glutamicum, Bacillus cereus, B. subtilis* and *Aspergillus flavus* (Tatsadjieu *et al.,* 2003). According to Nwaiwu and Imo (1999), *Xylopia aethiopica* essential oil from Nigeria showed a fungi-toxic activity, at varying degrees, against the mycelial growth of three food-borne fungi (*Aspergillus fumigatus, A. nidulans* and *Mucor hiemalis*). Lemongrass essential oil had both antimicrobial acvtivity against many strains such as *Aspergillus flavus, Penicillium expansum, A. ochraceus, P. verrucosum, Listeria monocytogenes, S. aureus, E. coli, S. typhimurium* respectively (Burt, 2004; Nguefack *et al.,* 2004, 2009, 2012). Essential oil of *Zingiber officinale* is recognized to have antimicrobial activity against *Bacillus subtilis, Pseudomonas aeruginosa, Candida albicans, Aspergillus niger, Pencillium* spp. and *Saccharomyces cerevisiae* (Sasidharan and Menon, 2010).

Antimicrobial activity of Essential oils in foodsystems.

Spices and herbs can be used as an alternative preservative and pathogen-control method in food materials. Indeed, according to studies of Burt (2004), Dahouenon-Ahoussi *et al.* (2010), essential oil of *Mentha piperita* had been recognized as biopreservatives for Africa drink, low-fat yoghurt (dairy products), fish dishes and vegetables. The same report was for essential oils of clove and cinnamon on vegetable and dairy products. The main active essential oil was clove oil (Burt, 2004). According to Ranasinghe *et al.* (2002), cinnamon and clove essential oils could be used as antifungal agents to manage post fungal diseases of banana. *Xylopia aethiopica* fruit had a great potential to control *Sitophilus zeamais*, and therefore it could be used in the protection of maize grain from storage pest. Pesticidal properties of *Xylopia aethiopica* seem to be related to β-pinene and terpinene-4-ol concentrations (Kouninki *et al.,* 2007). Lemongrass essential oil had potential to preserve food such as rice, vegetable (Burt, 2004).

With reference to the Table 1, all the essential oils selected possess antimicrobial efficiency against both bacteria and fungi at different degree. Certain oils such as *Syzygium aromaticum, Cinnamomum. zeylanicum, Ocimum gratissimum* have large spectrum activity due to their composition in phenoloic compound. They constitute the more potential biopreservatives of food among these nine plants. Essential oils of *Syzygium aromaticum* seems to be the most effective essential oil which is more active against the majority of bacteria and moulds which affect the quality of foods. Its activity is due to high concentration in eugenol, a phenolic component recognize to be active against more pathogens.

Application of EOs of plant-origin antimicrobials such as leaves of *Allium sativum, Ocimum gratissimum, Zingiber officinale, Syzygium aromaticum, Pimenta racemosa, Cinnamomum zeylanicum, Xylopia aethiopica, Cymbopogon citratus and Mentha piperita* could be a potential alternative to synthetic preservatives for reasons that they have large spectrum activity against Gram negative bacteria, Gram positive bacteria and fungi which are known to be the main factor of food deterioration. Further studies are necessary to prove their potentiality in foods preserving including traditional cheese Wagashi manufactured in Benin.

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