International Journal of Research in Agriculture, Biology & Environment (IJAGRI)

E-ISSN : 2582-6107

DOI: 10.47504/IJAGRI.2020.5115

Volume 1 (2) 2020

www.ijagri.org

Outline of Animals and Plants-Based antimicrobial agents (NAA) in Antimicrobial food packaging (AFP): A new paradigm in food industry

Ali Raza Ishaq*[1], Fatima Noor[2], Ayesha Noor[1], Iqra Farzeen[1], Iqra Afzal[1], [3] Muhammad Ilyas

[1]Department of Zoology, Government College University Faisalabad, Pakistan

[2]Department of Bioinformatics and Biotechnology, Government College University Faisalabad, Pakistan

[3]Institute of Vertebrate Palaeontology and Palaeoanthropology, CAS, Beijing, China

ABSTRACT

Natural compounds due to their less toxicity for human health are desired for antimicrobial food packaging. Natural compounds derived from plants, animals and microorganisms such as oils, phenols, terpenes, aliphatic compounds, aldehydes, organic acids and glucosinolates. Polyphenol around food inhibits gas exchange, moisture, flavor and other soluble transfer, hence, increase shelf life. Less use of phenols in food is enhanced by using polyphenols in the food industry, that maintain superficial expression, lowering bacterial activity at upper surfaced of vegetables, fruits and raw muscle food. From hypothetical studies, it is estimated that synthetic or artificial antibacterial agents are more beneficial as compared to the natural. Microbe's free food is an innovative demand of the food industry and it is need of the hour to use cheaper safer and healthy ways for the preservation of food. The meat industry is dependent on the antimicrobial packaging which is necessary for the safety of the meat. Efficient packaging and antimicrobial agents are the main aspects of the best quality and safety of meat and meat products. This review gives new insight into natural compounds used for antimicrobial food packaging and the application of antimicrobial food packaging.

Keyword*: Antimicrobial packaging, Natural Compounds, Animal Based, Plant Based Applications, Food industry.*

INTRDUCTION

Food is indispensable material intended for acquisition of energy by organism to endure its life that must be rotted though fungal, microbial and poor packaging action (J. H. Han, 2005). So, food packaging is innovative technique to sanctuary quantity or quality of any food products for consumers (Brody, 2008). Earlier, packaging just means to protect the food but now-a-days it became permanent part of our life to enhance the lifetime of food products due to versatility in lifestyle of any progressive country. Therefore, active packaging (moisture absorber, oxygen scavenger and antimicrobial) smart/intelligent packaging (gas indicator, time-temperature indicator etc.) are very helpful to enhance the food quantity, quality and consumer requirement (Brody, 2008). Most of the countries focus on food and beverage packaging to increase their economic status such as America spend out 130$ billion on food packaging. Earlier from eighteen century, wrapping or packaging was not considered as scientific process so, cloths and newspaper were used to protect the food-product but in the beginning of eighteen century Napoleon invented the long-term packaging system to preserve the healthy food for his army (Fig .1).

Evolution of innovative antimicrobial packaging provide us long-term preservation (Robertson, 2016), to avoid any external contamination, sustained the quality of food (J. H. Han, 2005), stunt the destruction of food products, protect the any contact of abiotic (light, temperature) or biotic (microbial contact) factors and upgrade the quantity of food with minimal time utilization for demanding of customers (Risch, 2009). Main problems for spoilage of food such as orange, mangoes, banana, dairy products and cereals are oxidation, microbial spoilage and various metabolites during transport and processing (Nerín, Tovar, & Salafranca, 2008; Sanches-Silva et al., 2014).

Nitrogen, oxygen, carbon dioxide, argon, helium and other various gases are most beneficial for packaging of food through *improved atmosphere packaging method*. *Controlled atmosphere packaging* is another method for conserving food, also makes

food fresh and gorgeous for any communal through incessantly intensive care system. Exclusion of air during packaging consequence to get rid from many aerobic microbial agents such as bacteria, fungi and mould that triggered the degeneration of food by altering the chemical or physical properties of food that's why this method is called *Vacuum packaging system* (Zhou, Xu, & Liu, 2010).

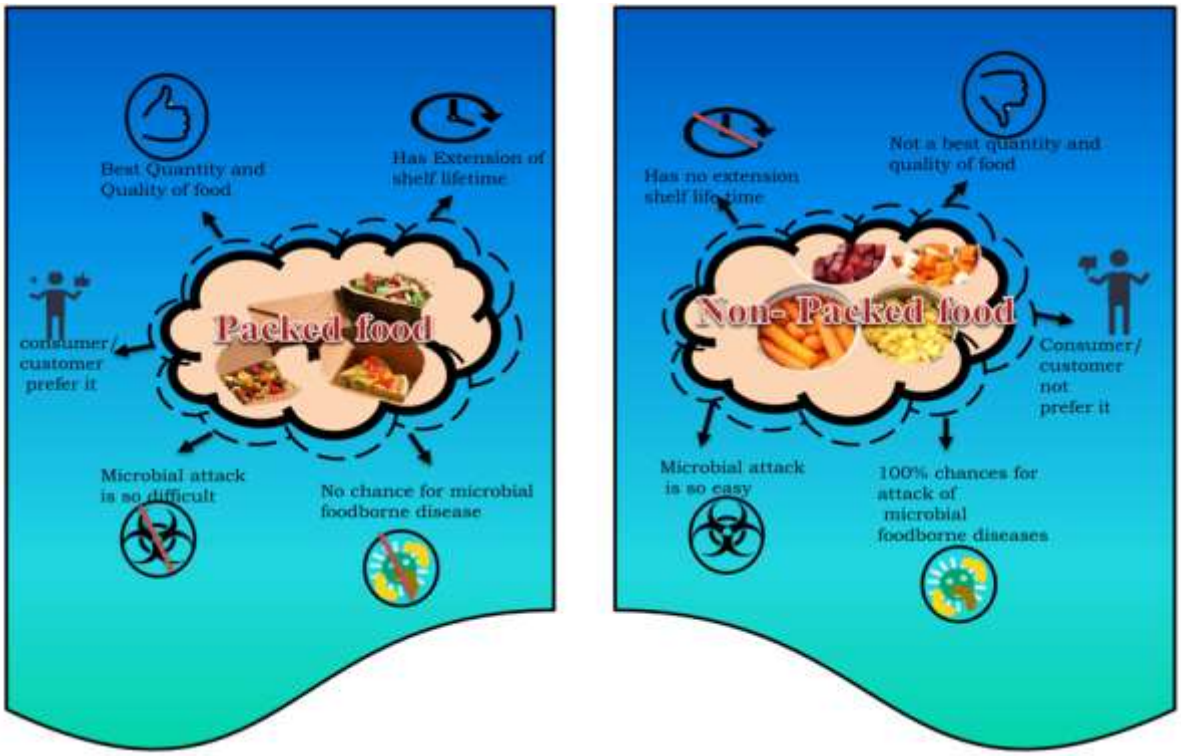

Figure 1 Schematic Introduction of food packaging

Accumulation of antimicrobial agent in the polymer film of packaging to stop the growth of a lot of microorganisms that cause problems in human body. Microbial agents well known as pathogens could be changed the homeostatic condition of our body cell or even misplaced the base pair sequence for specified protein.

This type of packaging must be sealed the growth of microbes by reducing the resources for microbes and the increase the preparatory phase (Lag phase) subsequently shelf-life time of food content in packaging system can be protected(J. H. Han, 2005). Packaging system introduce in scientific world due to conserve our food product, maintain quality and quantity of food and increased its shelf-life time by which researcher would focus on health problem. However most unadventurous technique was not found yet at industrial level, as soon as possible, our main intensive struggle must be invented novel chemicals and natural antimicrobial (bacteriocins) or antioxidants agents to develop the production of food(Quintavalla & Vicini, 2002). Several food packaging techniques are adopted but most furious is antimicrobial food packaging as shown Fig 2. This review paper efficiently proposed the animal and plant based antimicrobial agents, involved in antimicrobial food packaging.

DOI. 10.47504/IJAGRI.2020.5115

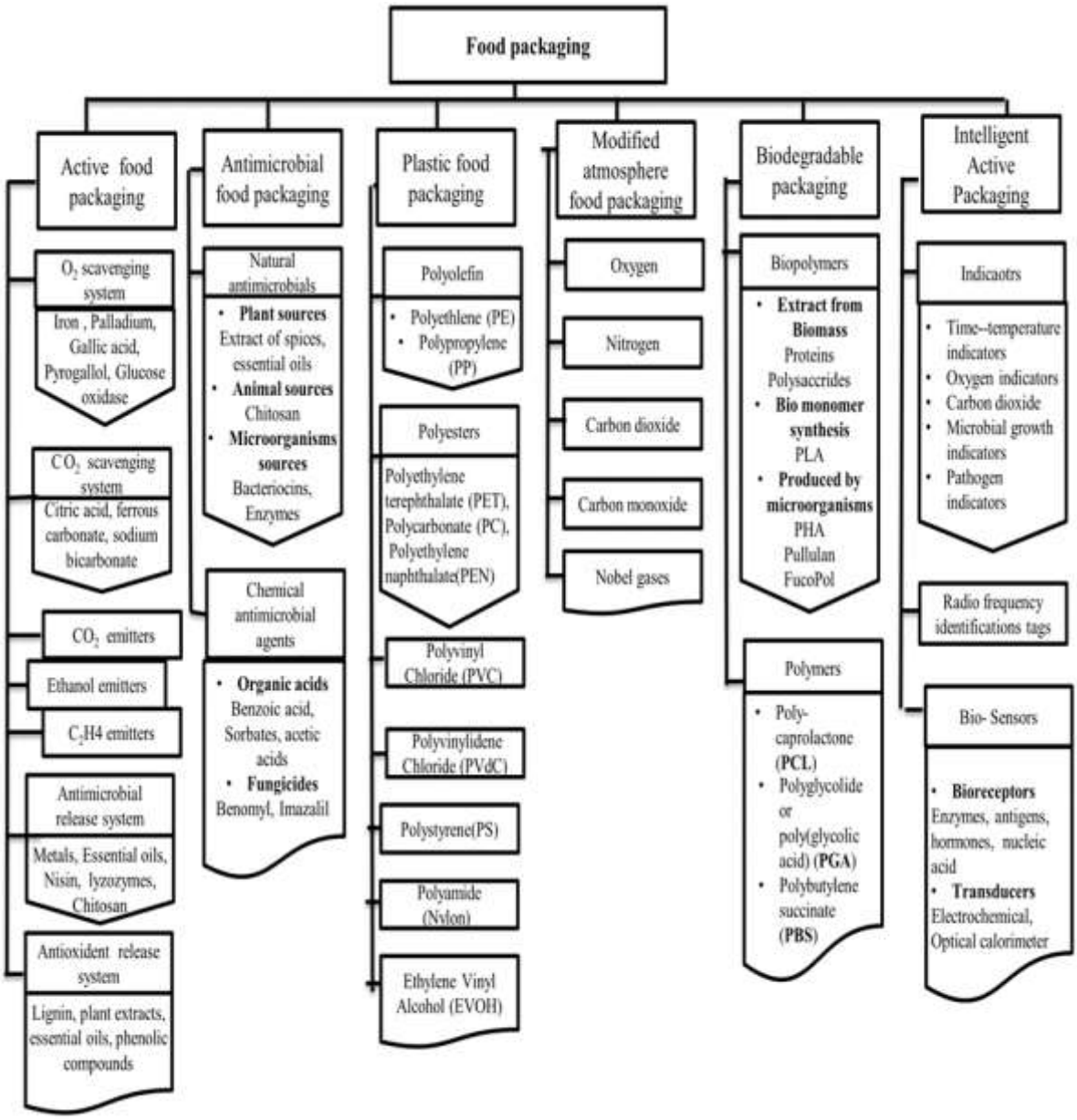

Figure 2 Schematic representation underlying types of food packaging

NATURAL ANTIMICROBIAL AGENTS:

The growing demand of organic food develop interest in antagonistic effect of natural compound in antimicrobial food packaging for long term use. The growth of pathogenic and spoilage microorganisms reduced recently by various natural products (Aloui & Khwaldia, 2016). The inhibition of microbial growth is major concern of food industries in 21st century for safety and reduction in waste destruction. Destruction by microbes is more than 40% in developed countries.

Majority natural agents derived from plants as essential oil, organic acids (ascorbic, sorbic, propionic and citric acid), bacteriocins from microorganisms (natamycin and nisin) and lactoferrin and lysozyme enzyme from animals source are natural agent for food packaging and to increase shelf life (Aloui & Khwaldia, 2016; Duran et al., 2016). Phenols develop recently in food industry. Basically, they categorized into three types 1. Polyphenols including tannins and flavonoid 2. Simple phenols consisting phenolic acid and coumarins 3. Volatile phenols.

Antimicrobial extract from single plant or more than one plant (mixture) is reported for food packaging (Bouarab Chibane, Degraeve, Ferhout, Bouajila, & Oulahal, 2019). In recent years consumer mostly used natural products rather than synthetic products, as they have less drawbacks (Cacho, Campillo, Viñas, & Hernández-Córdoba, 2016). Synthetic compounds effect human health by intestinal problem (Dastmalchi, Wang, & Stark, 2016; Lee & Paik, 2016). Natural products can derive from plants, animals and microbes and divided into groups on the base of origin and different delivery system. Mostly used natural

DOI. 10.47504/IJAGRI.2020.5115

compounds for food packaging are bacteriocins, enzymes and plant extracts as shown in Fig 3. In packaging antibacterial agent is lined, absorbed in products, absorbing or released compounds (He & Hwang, 2016).

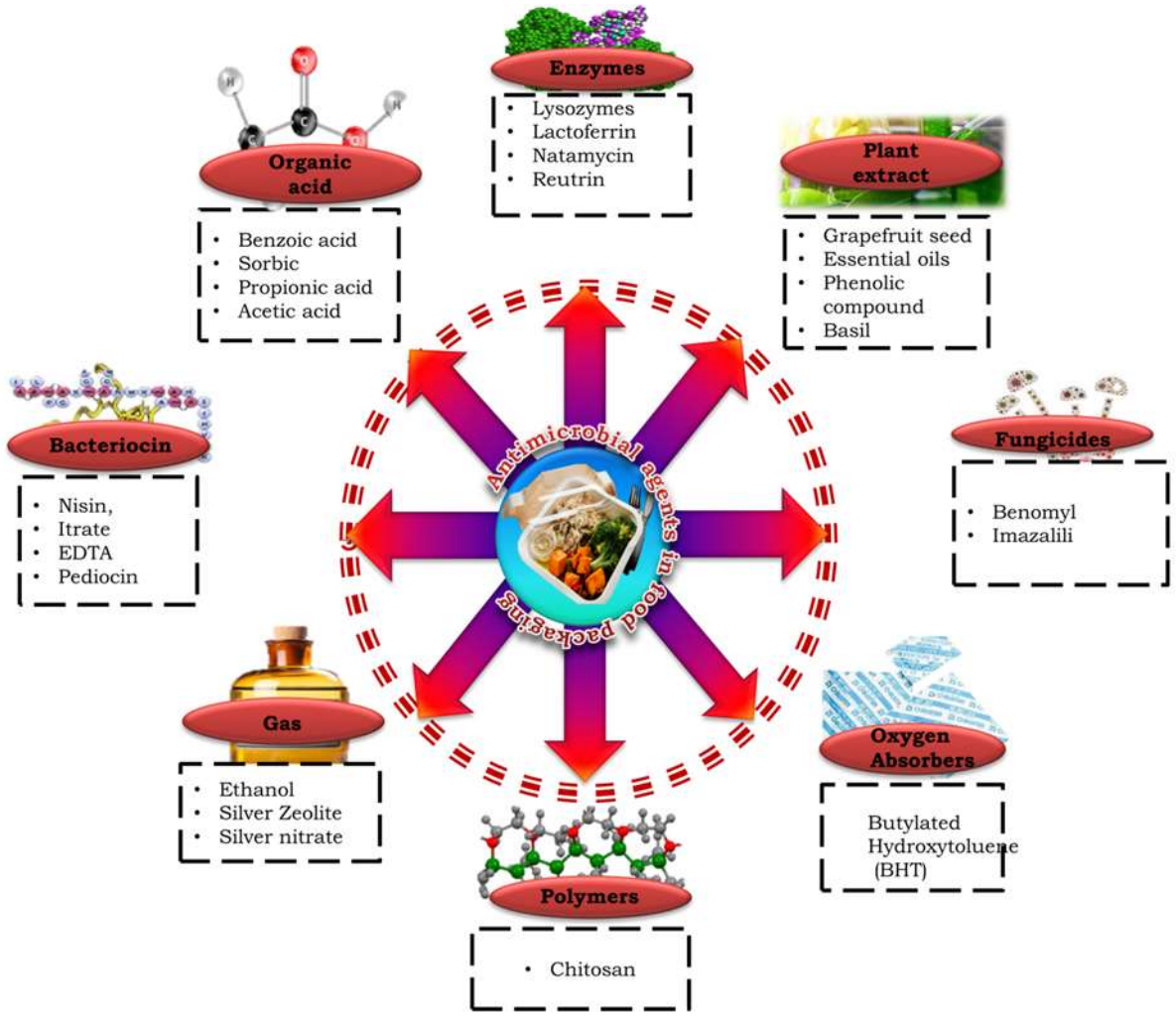

Figure 3 Summarize antimicrobial agents involves in the food packaging

PLANTS-BASED:

The big source of antimicrobial compound for packaging of food in industry is *plant*. Most commonly used antimicrobial agent from plants, herbs and spices are essential oils, phenols, terpenes, aliphatic compounds, organic acids, aldehyde (Pisoschi et al., 2018) and glucosinolates used by our ancestor (Carocho, Barreiro, Morales, & Ferreira, 2014). Instead of use in medicines, essential oil, by-product of plant extract such as secondary metabolites and hydrosol capable to inhibit microbial growth. Plant extracts are important due to their colour, nutritional value and taste characteristics. Polyphenols can match these characteristics for preservation of food. They have antioxidant property like rosemary extract that have above than 900gKg^{-1} carnosic acid and carnosol, both are phenolic. Polyphenols also enhanced life of food coating material (Aloui & Khwaldia, 2016).

ESSENTIAL OILS also known as volatile oils. Essential oils are aromatic, oily liquid produced by plants, herbs and other species. They extracted from secondary metabolites or by steam distillation (Atarés & Chiralt, 2016; A. E. Kapetanakou & Skandamis, 2016). Many essential oils like cumin, thymus, oregano, sage, fennel, mint, laurel is extracted. They have high quality in terpenes, terpenoids and phenolic compounds (85%). The composition of essential oils vary in different plants as variation in seeds, leaves, fruit, stems and other parts (Raut & Karuppayil, 2014). These antimicrobial compounds are immobilized by encapsulation. Encapsulation is the method of coating of core material with small capsule. Nano-capsule function as protective film that avoid exposure(Honarvar, Hadian, & Mashayekh, 2016). It is investigated that antimicrobial characteristics of whey protein separated films of 1-4% oregano, rosemary and garlic essential oil applied against *E. coli*, *S. aurerus*, and *Salmonella entiritidis* etc (Ribeiro-Santos, Andrade, & Sanches-Silva, 2017). Essential oils have limited use in food packaging because they are volatile and low solubility and high oxidation potential, used for packaging of meat, cheese, fruits and vegetables (Maisanaba et al., 2017). Encapsulation accelerate oxidation stability, light induced reaction, temperature and moisture protecting

DOI. 10.47504/IJAGRI.2020.5115

antimicrobial activity (Shamaei, Seiiedlou, Aghbashlo, Tsotsas, & Kharaghani, 2017).The encapsulation also close components that are responsible for antimicrobial activity(Esfanjani & Jafari, 2016).

PHENOLICS COMPOUNDS include simple phenols, flavonoids extracted from different plant species. They are used in bio-based packaging of food. In edible films phenols used to inhibit microbial activity in food (Yu et al., 2013). According to an estimation of N, O carboxymethyl chitosan at different amount of methylcellulose containing caffeic acid incorporation enhanced 6-time antimicrobial efficiency against *E. coli* and 2 time increased against staphylococcus *aureus*. The result shows great antimicrobial activity against foodborne pathogen than control of composite film.

They are extracted from food derived plant that limited its toxicity. The OH functional group of polyphenols react with cell membrane of bacteria by hydrogen bonding (Liu, Pan, Li, Jie, & Zeng, 2017), binding may damage membrane causing loss of cellular content or reduce localization of electron across membrane that alternate ATP level of bacteria and may cause cell death. Lipophilic character of phenolic accelerated by membrane contact that increase antimicrobial activity. Gram negative bacteria are more resistant than Gram positive bacteria because gram negative bacteria have more stable membrane made up of lipopolysaccharide, reduce passage of phytochemicals.

Packaging of food with phytochemical rather than plastic fulfill consumer desire's biodegradable, natural and recyclable food packing. Many natural polyphenols exist in nature and used for food packing. Phenolic compounds in foodstuff show temperature variation (Bouarab Chibane et al., 2019). Phenolic with high melting temperature show more stability as botanical compound in food Coating. Polyphenols (bioactive) added into external surface, internal surface or multilayered structure(Quirós-Sauceda, Ayala-Zavala, Olivas, & González-Aguilar, 2014). Whey protein, chitosan, soy bean, cellulose carrageenan, pectin use as biopolymer for film coating (Colak, Gouanve, Degraeve, Espuche, & Prochazka, 2015).

TANNIN AND FLAVONOIDS use by their oxidation properties. Tannic acid and catechin entrapped in sodium/casein caseinate fil protect food from oxidation during storage. It is reported, tannic acid has high molecular weight and high scavenging activity. Other plant extract green tea extract (GTE), proanthocyanin (POC), grape seed phenol (GSP), ginger extract (Wagenlehner et al.) and Gingko leaf extract (GLE) used with gelatine based film as antioxidant (Li, Miao, Wu, Chen, & Zhang, 2014).

GRAPEFRUIT SEED EXTRACT (GFSE) is heat stable, consist of naringin, ascorbic acid, hesperidin's, and various acid such as Acetic acid. GFSC has antimicrobial efficiency against *L. monocytogens, E. coli*. It is reported, Polyethylene with 0.5 or 1% GFSE elevate storage time of beef.

ALLYL ISOTHIOCYANATE another pungent compound of Cruciferae, aliphatic compound in Black, brown mustard, wasabi and in common plants such as cabbage, broccoli, horseradish, Kale, turnip etc have antimicrobial application (Jideani & Vogt, 2016). It is effective against Mesophilic bacteria and Coliforms. Studies carried out AIDC activity against *penicillium commune*, *P. nalgiovens* and *Geotrichum candidum. Rheum palmatum* and *Coptis chinese* extracts have antimicrobial activity by LDPE. Caffeic acid, chlorogenic acid, protocatechuic acid are compound for antimicrobial properties of coffee (Pisoschi et al., 2018). *Oxygenated terpenes* such as hydroxylated such as thymol, carvacrol have better antimicrobial activity instead of simple monoterpenes. Crude extract from *Cinnamomum burmanii* have antibacterial activity against gram positive and gram-negative bacteria. Water extraction from olive leaves have antimicrobial activity. Olive's leaves antimicrobial activity present by phenolic compound such as caffeic acid.

PROPOLIS active agent extracted by honybees from plant consist of different chemical compound such as polyphenols (flavonoids aglycon, phenolic acid, phenolic aldehyde and ketones), sesquiterpene, coumarin, quinines inorganic acid having antibacterial and antioxidant activity. It is added into packaging film to enhance its properties (Siripatrawan & Vitchayakitti, 2016).

Essential oils approximately composed of Volatile phenols. It is reported that to study effect of alginate/carboxymethyl cellulose by cinnamon volatile phenol, neither cinnamaldehyde nor pure papaya show antimicrobial activity. They susceptible to Gram positive bacteria rather than Gram negative bacteria because latter have lipopolysaccharide hydrophobic film (Y. Han, Yu, & Wang, 2018). Use of essential oil in food industry require to understand its minimum inhibitory concentration, range of target organism, mode of action, volatility and components of food effect on antimicrobial property (Wen et al., 2016). Other phenols are preferable in use of food industry, because volatile phenols limited by flavour, odour and cost (Ribeiro-Santos et al., 2017).

ETHANOL is natural antimicrobial volatile compound that used in food industry for packaging and to elevate shelf life. High concentration causes sensory problem, high cost and other ethical issue, any treatment to reduce ethanol level not applicable. It applied by encapsulation as essential oil or as carrier (A. Kapetanakou, Agathaggelou, & Skandamis, 2014). Ethanol use in beverages and spirit as antimicrobial without any change its properties. It used over 100 of year to preserve fruit from fungi and act as surface disinfectant (Otoni, Espitia, Avena-Bustillos, & McHugh, 2016).

DOI. 10.47504/IJAGRI.2020.5115

BASIL is oldest species of *Ocimum* genus. It is culinary herb and its essential oil, used as flavouring and antimicrobial in sausage, baked food and condiment. Several basil oils extracted from leaves and top of flower by steam distillation. Coating basil oil on orange has long shelf life than uncoated ones. Growth inhibition of *L. curvatus* and *S. cerevisiae* in tomato juices by basil essential oil reported (Sakkas & Papadopoulou, 2017). Basil oil consist of camphor, methyl chavicol, eugenol etc (Chenni, El Abed, Rakotomanomana, Fernandez, & Chemat, 2016).

ORGANIC ACID AND THEIR SALTS are used in food packaging as antimicrobial. Mostly organic acid is sorbic, propionic, lactic, acetic and benzoic acid. They disturb cell membrane and macromolecules integrity of microorganism by nutrient transfer and metabolism. Among organic acid lactic acid is produced by fermentation. Other acids are extracted or synthesized from other chemicals. More than one acid more effective in food packaging safety.

ENZYMES:

Enzymes from animal source are widely used in food packaging in 21st century. They are immobilized in packing material. The immobilization by nanomaterial advancement emerged in food processing (Honarvar et al., 2016). Peptidoglycan is key component of Gram positive and Gram negative bacterial cell wall (Benbettaïeb et al., 2018). A *lysozyme*, single peptide lytic enzyme present in egg and milks, have enzymatic against beta 1-4 glyosidic linkage between N-acetylmuramic acid and N-acetyl glucosamine in peptidoglycan (Aziz & Karboune, 2018; Rollini et al., 2016)[31,32]. Lysozyme change structural integrity and hydrolyse cell wall (Ulbin-Figlewicz, Zimoch-Korzycka, & Jarmoluk, 2014). Hydrolysed immobilized on Poly vinyl alcohol (PVOH) is reported against *Alicyclobacillus acidoterrestris.* Any bonding material added in polymer matrix for binding. They are attached with foodstuff either by monolayer cross linking with polyvinyl alcohol or multilayer structure by crossing of PVOH films.

The antibacterial activity of lysozymes with PVOH, cellulose and nylon against *Micrococcus lysodeikticus* cells observed, cellulose immobilization have best result with high antimicrobial activity. Lysozymes with NA-alginate and K-carrageenan based film in *E. coli, S. entiridits* and *L. innocua*. Antimicrobial nanofilm of poly L-glutamic acid with edible protein hen egg lysozyme inhibit growth of *M. luteus.* Naringinase enzyme immobilization in food contact of cellulose acetate to reduce bitterness of citrus juice (Irkin & Esmer, 2015).

Lactoferrin a glycoprotein that have antimicrobials activity against gram positive, gram negative bacteria, fungus and parasites. Bacterial cellulose Lactoferrin from bacteria have high antimicrobial activity (Padrao et al., 2016). Some other enzymes such as *Reutrin***,** *natamycin* have antimicrobial activity in food preservation.

BACTERIOCINS:

Bacteriocins are antimicrobial peptide compound produced by bacteria. Mostly they are produced from lactic acid producing bacteria and safer in packaging (Aziz & Karboune, 2018). The antimicrobial biofilm of food by bacteriocins enhance quality, safety and shelf food. They are stable and do not produce any allergic reaction and easily degraded by protease enzymes in intestinal tract of human (Gharsallaoui, Oulahal, Joly, & Degraeve, 2016).

NISIN proteinoids compound extracted from *lactococcus lactic* stains that present in raw milk and fermented food. Nisin has great antimicrobial activity as gram positive bacteria like food spoilage microorganism *staphylococcus aureus* and Bacilli. It is also thermostable, non-toxic and sensitive to protease enzymes. It is used as natural preservation agent in diary and canned food. World Health organization stated nisin as generally recognized as safe (GRAS). Nisin used in pasteurized cheese, liquid eggs, dairy, vegetables, meat, fish, beverages and cereal based products (J. C. Santos et al., 2018; Vilela et al., 2018).

Various studies investigated, recent time nisin used as antimicrobial for food packaging as different films in different steps. Nisin are small molecule secreting peptide molecule after contact with food substances. They are used with acid or other substance in coating. Nisin shows greater activity with Ethylene diamine –tetra acetic acid (EDTA) because chelating agent enhance bacterial membrane permeability. rather than isolation. Gram negative bacteria are more sensitive to Nisin (Benbettaïeb, Debeaufort, & Karbowiak, 2019). Bacteriocins lactosin 705 and Lactosin AL 705 by Lactobacillus curvatus CRL 705, Bacteriocins 32y from *Lb.curvatus*, Enterocin 461 K from *enterococcus casseliflavus* 1M 461 k have antimicrobial packaging system. Nisin inhibit activity of pathogenic bacteria in hydrophobic film such as whey and soybean as compared to less hydrophobic films like wheat gluten film, because increased hydrophobicity accelerate Nisin as carrier to food (Guzmán, Acevedo, Romero, & Estrada, 2015).

DOI. 10.47504/IJAGRI.2020.5115

PEDIOCIN also heat stable bacterial derived antimicrobial agent extracted from *Pediococus acidilacti and podiococcus pentosaceus*. They are stable and active at pH 2-8. They active against *Enterococcus, clostridium, Lactobacillus, carnobacterium* and high antimicrobial activity against *L. monocytogens* (Aloui & Khwaldia, 2016).

APPLICATIONS OF ANTIMICROBIAL FOOD PACKAGING

Food festering is the major issue nowadays and the reason is microorganisms. The demand of the germ-free food packaging is increasing day by day. Antibacterial agents are necessary to discourage the growing bacteria in food. They are the cheap source as well. But the disadvantage is they have a level of toxicity in the food packaging. Now the need of the hour is to make some synthetic antibacterial agents which should be more active and less toxic (Huang, Qian, Wei, & Zhou, 2019). For the prolonged safety of meat and its products we need the best quality biopolymer. From the observational studies, it is proved that the pullulan is the best biopolymer we can use in the meat products. It is preferred as it has some unique characteristics related to the degradation of microbes(Trinetta & Cutter, 2016).

Best food packaging is very necessary to prevent the food material from microbes and to minimize the waste products. For the maintenance of a healthy ecosystem, packaging should be biodegradable. To enhance the properties of biopolymers we use different kinds of nanomaterials. The addition of these nanomaterials increases the life of packaged food(Al-Tayyar, Youssef, & Al-Hindi, 2020). To make the meat industry profitable and according to the consumer choice the first concern is to make the quality better and safe from microbes like different kinds of bacteria (Fang, Zhao, Warner, & Johnson, 2017).

In the age of biotechnology, we can't sacrifice the taste and flavour of food. The hypothetical studies were conducted which indicate that the nanotechnology is best for the food packaging (Emanuel & Sandhu, 2020). From the observational studies it is concluded that synthetic antimicrobial agents have some negative impacts on the wrapped food. It is estimated that essential oils have great proficiency as antimicrobial agents in food packaging. These essential oils are used under the famous techniques of encapsulation (Zanetti et al., 2018).

From the observational analysis it is estimated that essential oils are beneficial antibacterial agents. It is also concluded that they have efficient work for the elimination of bacteria instead of reducing or minimize the growth of bacteria. That's why essential oils have high applications in the food industry (M. Santos et al., 2017). It is observed that antibacterial agents are necessary for the safety of food and to make their life shell long-lasting. From the hypothetical studies, it is estimated that chemical antimicrobial agents have some negative impact on the food quality could be dangerous for human health as well, but the multicomponent agents are beneficial. These agents have a mixture of natural and synthetic extracts that enhance their quality and properties which have a positive impact on the food surfaces and used as food sanitizers in the food industry. So they are very important from the commercial point of view (Park et al., 2020).

Essential oils have their applications in the medical industry.it is estimated that carvacrol is very sensitive towards bacteria either it is gram-positive or gram-negative. It can destroy the growth and development of both the bacterial types that's why it is commonly used in the medical industry nowadays (Marinelli, Di Stefano, & Cacciatore, 2018). Nowadays the use of antibacterial agents is like the use of the weapon in war. Researchers isolate the resistant bacteria from the human and the animal body and they try to use them as the antimicrobial agents.

Nowadays different techniques are used to enhance the yield and proficiency of the natural antibacterial agents. These techniques have improved the quality of the natural antibacterial agents and sure the security of the packaging food (Lorenzo et al., 2019). Nowadays the major threats of pathogens are to the food industry. It is very difficult to cope with the situations because the pathogens have high growth rats and become resistant to the antibacterial agents. In this situation, everyone seems to be hopeless and helpless. But scientists have some solutions for this kind of situation. Probiotics are the live microbes that are provided to humans and animals. They act as the antibacterial agents in the intestinal tract and could fight with the harmful microbes in the ingested food. Probiotics have great applications in the food industries, aquaculture, and agriculture, etc (Hossain, Sadekuzzaman, & Ha, 2017).

From the observational studies, it is estimated that spices of different plants and different types are used in the food industry. Spices like clove, cinnamon pepper, etc. are very important commercially. All they have some chemical naturally which has the antioxidant and antibacterial properties that's why they are used in the food industry. They have special importance in the meat industry, they are also used in the packaging of their foodstuff as they have antibacterial properties naturally. They are also used as colour and flavour additives (Jessica Elizabeth, Gassara, Kouassi, Brar, & Belkacemi, 2017). From the hypothetical analysis, it is concluded that sea cucumber has great importance in the medical and food point of view. It is estimated that is has been used in the past as medicine in wound healing and nowadays it is estimated that it has antibacterial and antioxidant properties. Nowadays it is used in the medicine and food industry in most of the regions in Asia (Pangestuti & Arifin, 2018).

DOI. 10.47504/IJAGRI.2020.5115

In the Food Industry, the use of antibacterial agents is going towards increase. For food safety to make a good taste and long-lasting it is necessary to use these agents. To fulfil the demands of the consumer there are different techniques to prepare the antibacterial agents. Active packaging is widely used in the food industry. It is beneficial for food safety and there is no loss of food while using active packaging. It is estimated that in the coming years it will the most successful and common in all types of food industries(Wyrwa & Barska, 2017). Methods of natural preservation are famous nowadays. Antimicrobial agents that are used in this method are extruded from plants, microbes, and animals for the preservation of food to avoid it from rotten. Researchers are trying to use the natural antimicrobial agents instead of synthetic agents which have some disadvantages. Essential oils were used for many decades as natural antimicrobial agents. But nowadays there are some aromatic oils are used for preservation. These aromatic oils are extracted from different parts of the plants. It's going to be trendier to use the natural antimicrobial agents because of their proficiency(Amenu Delesa, 2018). From the observational studies it is concluded that certain species of bacteria became resistant to antibiotics and antibacterial agents. They have many species listed by WHO. They are a major threat to humans. Now some solutions are found to cope with the situations. Firstly by destroying their action mechanism and second using some special bacteriophages (Breijyeh, Jubeh, & Karaman, 2020).

Bacteria and the other microbes are a major threat to the food industry. The scientist is trying their best to save the food from spoilage so from the different techniques the most important is starter culture. This is very important for the security of food items especially meat and meat products. This culture is also reducing the use of chemical additives which may have some negative impact on human health. Starter culture may enhance the characteristics of fermented food items in their yield and productivity (Laranjo, Potes, & Elias, 2019). It is estimated that the antimicrobial additives in different kinds of food have a great impact on the human gut microbes. They can change the growth of these microbes. It is observed that the exposure of gut microbes to the antimicrobial agents or additives in food have some positive results. It is concluded from the hypothetical analysis that the additives or the antimicrobial agents increase the growth of gut microbes which enhance the immune system as a result. It is also estimated that these additives must be used in low amounts. On the other hand, the side effects in a small no can be seen(Hrncirova et al., 2019) but antimicrobial packaging gives us several advantages which are listed in Table 1.

Table 1 : Summarize the advantages of Antimicrobial food packaging

Sr.No	Advantages of Food Packaging	References
01	Food packaging provided us great deal with microbial attack. It protects our food-based from microorganism contamination.	[11]
02	Food packaging cannot direct enter of light in material that spoiled the food by changing its mechanical and physical properties.	
03	Food packaging also requiring a secure ground from moisture and contact with oxygen to packed material.	
04	Food packaging also extents the shelf lifetime of our packed food through extraction of various hazard materials.	[80, 81]
05	Antimicrobial packaging also stunts the growth of various microorganisms in packed food to enhance its quality and quantity.	[10, 82]

During scientific studies, some natural additives were collected from the floral biodiversity of Malaysia. The plant extracts which were used as the antibacterial agents in the form of the thin eatable film have great impacts on the foody products. These additives enhanced the life of packaged food and minimize waste materials(Mustapha, Jai, Hamidon, Sharif, & Yusof, 2017). To make the food available and according to the consumer choice, every market is trying to make healthy and long-lasting food products. They try to make some renewable sources in this regard agro by-products are the best additives ever used in the market. These are the by-products of already used food additives. They are natural and have low costs and limit the dependency on chemical antibacterial additives. This is nature friendly and economically as well(Faustino et al., 2019). From the observational studies, it is concluded that traditional food preservation is time-consuming, so we are looking for non-traditional methods. Sometimes food is treated with the temperature 60-100^{o}C to destroy the bacteria. After that, some antibacterial agents are also used to make food safety long-lasting. It is necessary to deactivate the enzymes and microbes, for the flavour and aroma of the packaged food. These

DOI. 10.47504/IJAGRI.2020.5115

antibacterial agents are derived from the animals or plants, added to the preserved food and the process is called bio preservation (Nazir, Salim, Yousf, BashirM, & Hussain, 2017).

CONCLUSION

Antimicrobial agents which nature-derivative including bacteriocin, phenolic compounds and enzymes extensively used in antimicrobial packaging system to enhance the shelf life of food items. These agents are bio-friendly, no threat to life of organism whatever to enhance the quality of food and no side effect on human are result of antimicrobial packaging. Antimicrobial packaging is wide used in the global food industry including Europe, Asia and Africa. Combating with microbial diseases is achieved by enhancing the quality of food and its packing to introduce the nature-based antimicrobial agents.

REFERENCES

1. Al-Tayyar, N. A., Youssef, A. M., & Al-Hindi, R. (2020). Antimicrobial food packaging based on sustainable Bio-based materials for reducing foodborne Pathogens: A review. *Food chemistry*, *310*, 125915.
2. Aloui, H., & Khwaldia, K. (2016). Natural antimicrobial edible coatings for microbial safety and food quality enhancement. *Comprehensive Reviews in Food Science and Food Safety*, *15*(6), 1080-1103.
3. Amenu Delesa, D. (2018). Traditional Medicinal Plants for Industrial Application as Natural Food Preservatives. *International Journal of Advanced Biological and Biomedical Research (IJABBR)*, *6*, 1-10.
4. Andersen, B. M. (2019). Antibacterial Agents and Drug Resistance *Prevention and Control of Infections in Hospitals* (pp. 29-43): Springer.
5. Andrade, M. A., Ribeiro-Santos, R., Bonito, M. C. C., Saraiva, M., & Sanches-Silva, A. (2018). Characterization of rosemary and thyme extracts for incorporation into a whey protein based film. *Lwt*, *92*, 497-508.
6. Atarés, L., & Chiralt, A. (2016). Essential oils as additives in biodegradable films and coatings for active food packaging. *Trends in food science & technology*, *48*, 51-62.
7. Aziz, M., & Karboune, S. (2018). Natural antimicrobial/antioxidant agents in meat and poultry products as well as fruits and vegetables: A review. *Critical reviews in food science and nutrition*, *58*(3), 486-511.
8. Benbettaïeb, N., Debeaufort, F., & Karbowiak, T. (2019). Bioactive edible films for food applications: Mechanisms of antimicrobial and antioxidant activity. *Critical reviews in food science and nutrition*, *59*(21), 3431-3455.
9. Benbettaïeb, N., Tanner, C., Cayot, P., Karbowiak, T., & Debeaufort, F. (2018). Impact of functional properties and release kinetics on antioxidant activity of biopolymer active films and coatings. *Food chemistry*, *242*, 369-377.
10. Bouarab Chibane, L., Degraeve, P., Ferhout, H., Bouajila, J., & Oulahal, N. (2019). Plant antimicrobial polyphenols as potential natural food preservatives. *Journal of the Science of Food and Agriculture*, *99*(4), 1457-1474.
11. Breijyeh, Z., Jubeh, B., & Karaman, R. (2020). Resistance of Gram-negative bacteria to current antibacterial agents and approaches to resolve it. *Molecules*, *25*(6), 1340.
12. Brody, A. L. (2008). Packaging by the numbers. *Food technology*.
13. Cacho, J. I., Campillo, N., Viñas, P., & Hernández-Córdoba, M. (2016). Determination of synthetic phenolic antioxidants in edible oils using microvial insert large volume injection gas-chromatography. *Food Chemistry*, *200*, 249-254.
14. Carocho, M., Barreiro, M. F., Morales, P., & Ferreira, I. C. (2014). Adding molecules to food, pros and cons: A review on synthetic and natural food additives. *Comprehensive Reviews in Food Science and Food Safety*, *13*(4), 377-399.
15. Chenni, M., El Abed, D., Rakotomanomana, N., Fernandez, X., & Chemat, F. (2016). Comparative study of essential oils extracted from Egyptian basil leaves (Ocimum basilicum L.) using hydro-distillation and solvent-free microwave extraction. *Molecules*, *21*(1), 113.
16. Colak, B. Y., Gouanve, F., Degraeve, P., Espuche, E., & Prochazka, F. (2015). Study of the influences of film processing conditions and glycerol amount on the water sorption and gas barrier properties of novel sodium caseinate films. *Journal of Membrane Science*, *478*, 1-11.
17. Dastmalchi, K., Wang, I., & Stark, R. E. (2016). Potato wound-healing tissues: A rich source of natural antioxidant molecules with potential for food preservation. *Food Chemistry*, *210*, 473-480.
18. Duran, M., Aday, M. S., Zorba, N. N. D., Temizkan, R., Büyükcan, M. B., & Caner, C. (2016). Potential of antimicrobial active packaging 'containing natamycin, nisin, pomegranate and grape seed extract in chitosan coating'to extend shelf life of fresh strawberry. *Food and Bioproducts Processing*, *98*, 354-363.
19. Echeverría, I., López-Caballero, M. E., Gómez-Guillén, M. C., Mauri, A. N., & Montero, M. P. (2018). Active nanocomposite films based on soy proteins-montmorillonite-clove essential oil for the preservation of refrigerated bluefin tuna (Thunnus thynnus) fillets. *International journal of food microbiology*, *266*, 142-149.
20. Emanuel, N., & Sandhu, H. K. (2020). Food Packaging Development: Recent Perspective. *Journal of Thin Films, Coating Science Technology and Application*, *6*(3), 13-29.

DOI. 10.47504/IJAGRI.2020.5115

21. Esfanjani, A. F., & Jafari, S. M. (2016). Biopolymer nano-particles and natural nano-carriers for nano-encapsulation of phenolic compounds. *Colloids and Surfaces B: Biointerfaces, 146*, 532-543.
22. Fang, Z., Zhao, Y., Warner, R. D., & Johnson, S. K. (2017). Active and intelligent packaging in meat industry. *Trends in Food Science & Technology, 61*, 60-71.
23. Faustino, M., Veiga, M., Sousa, P., Costa, E. M., Silva, S., & Pintado, M. (2019). Agro-food byproducts as a new source of natural food additives. *Molecules, 24*(6), 1056.
24. Gharsallaoui, A., Oulahal, N., Joly, C., & Degraeve, P. (2016). Nisin as a food preservative: part 1: physicochemical properties, antimicrobial activity, and main uses. *Critical reviews in food science and nutrition, 56*(8), 1262-1274.
25. Guzmán, L. E., Acevedo, D., Romero, L., & Estrada, J. (2015). Elaboración de una película comestible a base de colágeno incorporado con nisina como agente antimicrobiano. *Información tecnológica, 26*(3), 17-24.
26. Han, J. H. (2005). New technologies in food packaging: Overiew *Innovations in food packaging* (pp. 3-11): Elsevier.
27. Han, Y., Yu, M., & Wang, L. (2018). Physical and antimicrobial properties of sodium alginate/carboxymethyl cellulose films incorporated with cinnamon essential oil. *Food Packaging and Shelf Life, 15*, 35-42.
28. He, X., & Hwang, H.-M. (2016). Nanotechnology in food science: Functionality, applicability, and safety assessment. *journal of food and drug analysis, 24*(4), 671-681.
29. Honarvar, Z., Hadian, Z., & Mashayekh, M. (2016). Nanocomposites in food packaging applications and their risk assessment for health. *Electronic physician, 8*(6), 2531.
30. Hoseinnejad, M., Jafari, S. M., & Katouzian, I. (2018). Inorganic and metal nanoparticles and their antimicrobial activity in food packaging applications. *Critical reviews in microbiology, 44*(2), 161-181.
31. Hossain, M. I., Sadekuzzaman, M., & Ha, S.-D. (2017). Probiotics as potential alternative biocontrol agents in the agriculture and food industries: A review. *Food Research International, 100*, 63-73.
32. Hrncirova, L., Hudcovic, T., Sukova, E., Machova, V., Trckova, E., Krejsek, J., & Hrncir, T. (2019). Human gut microbes are susceptible to antimicrobial food additives in vitro. *Folia microbiologica, 64*(4), 497-508.
33. Huang, T., Qian, Y., Wei, J., & Zhou, C. (2019). Polymeric antimicrobial food packaging and its applications. *Polymers, 11*(3), 560.
34. Irkin, R., & Esmer, O. K. (2015). Novel food packaging systems with natural antimicrobial agents. *Journal of food science and technology, 52*(10), 6095-6111.
35. Jessica Elizabeth, D. L. T., Gassara, F., Kouassi, A. P., Brar, S. K., & Belkacemi, K. (2017). Spice use in food: Properties and benefits. *Critical reviews in food science and nutrition, 57*(6), 1078-1088.
36. Jideani, V. A., & Vogt, K. (2016). Antimicrobial packaging for extending the shelf life of bread—A review. *Critical reviews in food science and nutrition, 56*(8), 1313-1324.
37. Kapetanakou, A., Agathaggelou, E., & Skandamis, P. (2014). Storage of pork meat under modified atmospheres containing vapors from commercial alcoholic beverages. *International journal of food microbiology, 178*, 65-75.
38. Kapetanakou, A. E., & Skandamis, P. N. (2016). Applications of active packaging for increasing microbial stability in foods: natural volatile antimicrobial compounds. *Current Opinion in Food Science, 12*, 1-12.
39. Krepker, M., Shemesh, R., Poleg, Y. D., Kashi, Y., Vaxman, A., & Segal, E. (2017). Active food packaging films with synergistic antimicrobial activity. *Food Control, 76*, 117-126.
40. Laranjo, M., Potes, M. E., & Elias, M. (2019). Role of starter cultures on the safety of fermented meat products. *Frontiers in microbiology, 10*, 853.
41. Lee, N.-K., & Paik, H.-D. (2016). Status, antimicrobial mechanism, and regulation of natural preservatives in livestock food systems. *Korean journal for food science of animal resources, 36*(4), 547.
42. Li, J.-H., Miao, J., Wu, J.-L., Chen, S.-F., & Zhang, Q.-Q. (2014). Preparation and characterization of active gelatin-based films incorporated with natural antioxidants. *Food Hydrocolloids, 37*, 166-173.
43. Liu, Z., Pan, Y., Li, X., Jie, J., & Zeng, M. (2017). Chemical composition, antimicrobial and anti-quorum sensing activities of pummelo peel flavonoid extract. *Industrial Crops and Products, 109*, 862-868.
44. Lorenzo, J. M., Mousavi Khaneghah, A., Gavahian, M., Marszałek, K., Eş, I., Munekata, P. E., . . . Barba, F. J. (2019). Understanding the potential benefits of thyme and its derived products for food industry and consumer health: From extraction of value-added compounds to the evaluation of bioaccessibility, bioavailability, anti-inflammatory, and antimicrobial activities. *Critical reviews in food science and nutrition, 59*(18), 2879-2895.
45. Maisanaba, S., Llana-Ruiz-Cabello, M., Gutiérrez-Praena, D., Pichardo, S., Puerto, M., Prieto, A., . . . Cameán, A. (2017). New advances in active packaging incorporated with essential oils or their main components for food preservation. *Food Reviews International, 33*(5), 447-515.
46. Marinelli, L., Di Stefano, A., & Cacciatore, I. (2018). Carvacrol and its derivatives as antibacterial agents. *Phytochemistry Reviews, 17*(4), 903-921.
47. Motey, R., & Lele, S. (2003). Plastic Films for Processed Foods-Special Requirements. *Packaging India, 35*(5), 19-32.
48. Mustapha, F., Jai, J., Hamidon, F., Sharif, Z. M., & Yusof, N. M. (2017). Antimicrobial agents from Malaysian plants and their potential use in food packaging material. *Chemical Engineering Research Bulletin*, 57-66.

49. Nazir, F., Salim, R., Yousf, N., BashirM, N. H., & Hussain, S. (2017). Natural antimicrobials for food preservation. *J Pharmacogn Phytochem, 6*(6), 2078-2082.
50. Nerín, C., Tovar, L., & Salafranca, J. (2008). Behaviour of a new antioxidant active film versus oxidizable model compounds. *Journal of food Engineering, 84*(2), 313-320.
51. Otoni, C. G., Espitia, P. J., Avena-Bustillos, R. J., & McHugh, T. H. (2016). Trends in antimicrobial food packaging systems: Emitting sachets and absorbent pads. *Food Research International, 83*, 60-73.
52. Padrao, J., Gonçalves, S., Silva, J. P., Sencadas, V., Lanceros-Méndez, S., Pinheiro, A. C., . . . Dourado, F. (2016). Bacterial cellulose-lactoferrin as an antimicrobial edible packaging. *Food Hydrocolloids, 58*, 126-140.
53. Pangestuti, R., & Arifin, Z. (2018). Medicinal and health benefit effects of functional sea cucumbers. *Journal of traditional and complementary medicine, 8*(3), 341-351.
54. Park, K. M., Yoon, S.-G., Choi, T.-H., Kim, H. J., Park, K. J., & Koo, M. (2020). The Bactericidal Effect of a Combination of Food-Grade Compounds and their Application as Alternative Antibacterial Agents for Food Contact Surfaces. *Foods, 9*(1), 59.
55. Persico, P., Ambrogi, V., Carfagna, C., Cerruti, P., Ferrocino, I., & Mauriello, G. (2009). Nanocomposite polymer films containing carvacrol for antimicrobial active packaging. *Polymer Engineering & Science, 49*(7), 1447-1455.
56. Pisoschi, A. M., Pop, A., Georgescu, C., Turcuş, V., Olah, N. K., & Mathe, E. (2018). An overview of natural antimicrobials role in food. *European Journal of Medicinal Chemistry, 143*, 922-935.
57. Quintavalla, S., & Vicini, L. (2002). Antimicrobial food packaging in meat industry. *Meat science, 62*(3), 373-380.
58. Quinto, E. J., Caro, I., Villalobos-Delgado, L. H., Mateo, J., De-Mateo-Silleras, B., & Redondo-Del-Río, M. P. (2019). Food safety through natural antimicrobials. *Antibiotics, 8*(4), 208.
59. Quirós-Sauceda, A. E., Ayala-Zavala, J. F., Olivas, G. I., & González-Aguilar, G. A. (2014). Edible coatings as encapsulating matrices for bioactive compounds: a review. *Journal of food science and technology, 51*(9), 1674-1685.
60. Raut, J. S., & Karuppayil, S. M. (2014). A status review on the medicinal properties of essential oils. *Industrial Crops and Products, 62*, 250-264.
61. Ribeiro-Santos, R., Andrade, M., & Sanches-Silva, A. (2017). Application of encapsulated essential oils as antimicrobial agents in food packaging. *Current Opinion in Food Science, 14*, 78-84.
62. Risch, S. J. (2009). Food packaging history and innovations. *Journal of agricultural and food chemistry, 57*(18), 8089-8092.
63. Robertson, G. L. (2016). *Food packaging: principles and practice*: CRC press.
64. Rollini, M., Nielsen, T., Musatti, A., Limbo, S., Piergiovanni, L., Hernandez Munoz, P., & Gavara, R. (2016). Antimicrobial performance of two different packaging materials on the microbiological quality of fresh salmon. *Coatings, 6*(1), 6.
65. Sakkas, H., & Papadopoulou, C. (2017). Antimicrobial activity of basil, oregano, and thyme essential oils. *Journal of microbiology and biotechnology, 27*(3), 429-438.
66. Sanches-Silva, A., Costa, D., Albuquerque, T. G., Buonocore, G. G., Ramos, F., Castilho, M. C., . . . Costa, H. S. (2014). Trends in the use of natural antioxidants in active food packaging: a review. *Food Additives & Contaminants: Part A, 31*(3), 374-395.
67. Santos, J. C., Sousa, R. C., Otoni, C. G., Moraes, A. R., Souza, V. G., Medeiros, E. A., . . . Soares, N. F. (2018). Nisin and other antimicrobial peptides: Production, mechanisms of action, and application in active food packaging. *Innovative Food Science & Emerging Technologies, 48*, 179-194.
68. Santos, M., Martins, S., Veríssimo, C., Nunes, M., Lima, A., Ferreira, R., . . . Ferreira, M. (2017). Essential oils as antibacterial agents against food-borne pathogens: Are they really as useful as they are claimed to be? *Journal of food science and technology, 54*(13), 4344-4352.
69. Shamaei, S., Seiiedlou, S. S., Aghbashlo, M., Tsotsas, E., & Kharaghani, A. (2017). Microencapsulation of walnut oil by spray drying: Effects of wall material and drying conditions on physicochemical properties of microcapsules. *Innovative food science & emerging technologies, 39*, 101-112.
70. Siripatrawan, U., & Vitchayakitti, W. (2016). Improving functional properties of chitosan films as active food packaging by incorporating with propolis. *Food Hydrocolloids, 61*, 695-702.
71. Song, X., Zuo, G., & Chen, F. (2018). Effect of essential oil and surfactant on the physical and antimicrobial properties of corn and wheat starch films. *International journal of biological macromolecules, 107*, 1302-1309.
72. Trinetta, V., & Cutter, C. (2016). Pullulan: A suitable biopolymer for antimicrobial food packaging applications *Antimicrobial Food Packaging* (pp. 385-397): Elsevier.
73. Ulbin-Figlewicz, N., Zimoch-Korzycka, A., & Jarmoluk, A. (2014). Antibacterial activity and physical properties of edible chitosan films exposed to low-pressure plasma. *Food and Bioprocess Technology, 7*(12), 3646-3654.
74. Valdés, A., Ramos, M., Beltrán, A., Jiménez, A., & Garrigós, M. C. (2017). State of the art of antimicrobial edible coatings for food packaging applications. *Coatings, 7*(4), 56.

75. Vermeiren, L., Devlieghere, F., van Beest, M., de Kruijf, N., & Debevere, J. (1999). Developments in the active packaging of foods. *Trends in food science & technology, 10*(3), 77-86.
76. Vilela, C., Kurek, M., Hayouka, Z., Röcker, B., Yildirim, S., Antunes, M. D. C., . . . Freire, C. S. (2018). A concise guide to active agents for active food packaging. *Trends in Food Science & Technology, 80*, 212-222.
77. Wagenlehner, F. M., Lichtenstern, C., Rolfes, C., Mayer, K., Uhle, F., Weidner, W., & Weigand, M. A. (2013). Diagnosis and management for urosepsis. *International Journal of Urology, 20*(10), 963-970.
78. Wen, P., Zhu, D.-H., Wu, H., Zong, M.-H., Jing, Y.-R., & Han, S.-Y. (2016). Encapsulation of cinnamon essential oil in electrospun nanofibrous film for active food packaging. *Food Control, 59*, 366-376.
79. Wyrwa, J., & Barska, A. (2017). Innovations in the food packaging market: active packaging. *European Food Research and Technology, 243*(10), 1681-1692.
80. Yu, S.-H., Hsieh, H.-Y., Pang, J.-C., Tang, D.-W., Shih, C.-M., Tsai, M.-L., . . . Mi, F.-L. (2013). Active films from water-soluble chitosan/cellulose composites incorporating releasable caffeic acid for inhibition of lipid oxidation in fish oil emulsions. *Food Hydrocolloids, 32*(1), 9-19.
81. Zahra, S. A., Butt, Y. N., Nasar, S., Akram, S., Fatima, Q., & Ikram, J. (2019). Food packaging in perspective of microbial activity: a review. *Journal of Microbiology, Biotechnology and Food Sciences, 2019*, 752-757.
82. Zanetti, M., Carniel, T. K., Dalcanton, F., dos Anjos, R. S., Riella, H. G., de Araujo, P. H., . . . Fiori, M. A. (2018). Use of encapsulated natural compounds as antimicrobial additives in food packaging: A brief review. *Trends in Food Science & Technology, 81*, 51-60.
83. Zhou, G., Xu, X., & Liu, Y. (2010). Preservation technologies for fresh meat–A review. *Meat science, 86*(1), 119-128.