

Review Article

Prolonged the Shelf Life of Different Foods using the Citrus By-Products as Antimicrobials: A Review Article

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Abstract

A novel type of packaging that combines food packaging materials with antimicrobial substances to control microbial surface contamination of foods to enhance product microbial safety and to extend shelf-life is attracting interest in the packaging industry. In agreement with the current trend of giving value to natural and renewable resources, the use of natural antimicrobial compounds, particularly in food and biomedical applications, becomes very frequent. The direct addition of natural compounds to food is the most common method of application, even if numerous efforts have been made to find alternative solutions to the aim of avoiding undesirable inactivation. Dipping, spraying, and coating treatment of food with active solutions are currently applied to product prior to packaging as valid options.

Keywords: Antimicrobial compounds; Food preservation; Natural compounds; Food packaging; Natural antimicrobials

Prolonged Storage of Different Food by Using Citrus as Antimicrobial

At its known, the main factors that cause the deterioration in food quality and reduced their shelf life are bacterial growth and lipid oxidation [1,2]. So, there are demand for use chemical additives as a preservative to inhibit the spoilage of food by microorganism and lipid oxidation process. Nevertheless, nowadays the consumers become more aware about the defect of synthetic antimicrobial and antioxidants substances and their relationship about human health risk, which used for extend food shelf life [3]. So, the current tend to use the natural antimicrobial compounds for extend the shelf life of food [4]. Among of them, the antimicrobial and antioxidant that have been extracted from citrus, whether from peel, seed, pulp and essential oils and applied them in food products. Since its will known that the extracts consider as a high source of bio phytochemicals substances against microorganism, also they could be added in the food system to improve the quality and extend the shelf life [3].

A lot of phenolic compounds that have been reported in the citrus peels include flavonoids (flavonols, flavones, flavonones and coumarins), phenolic acids and monoterpene hydrocarbons [5]. Many studies have been conducted by using essential oils extracts from citrus peels, the results exhibited that the antimicrobial activity against *Salmonella typhi*, *Bacillus cereus* and *Staphylococcus aureus* [6], also in fruit products [7], chicken products [8]. Extracted bio phytochemical from citrus can be added to food either directly or incorporated in packaging system [9]. A new preservation method that used to improve the quality of food products, it's called Edible Films and Coating (EFC) by added with natural antimicrobial to inhibited food spoilage and growth of pathogenic microorganism [10].

Meat and meat products

Meat and meat products are considered a good source of protein and other nutrients like vitamin and minerals. It's defined by the

codex alimentarius [11] as a safe source and suitable for human consumption. Many of the factors that effect on the quality of meat such as pH, temperature, microbial growth and lipid oxidation ... etc. [12]. The deterioration that occur during the processing and storage of meat ref come back to three mechanisms: lipid oxidation, microbial spoilage and enzymatic autolysis [10].

Ethanol and ethyl acetate extraction of three type of citrus peel (kaffir lime, lime and pomelo) were studied in stored raw chicken drumettes at 4°C as antimicrobial and antioxidants for extension their shelf life. They were found to be more effective against pathogenic bacteria at level ranged from 0.4-50 mg/ml. also, they found that the treated chicken wing samples with ethyl acetate extracted from kaffir lime peel were lower than those of control sample in their values of total viable counts, 2-Thiobarbituric Acid Reactive Substances (TBARS) and increased the sensory properties during the period of storage (14 days) [13] (Table 1). In another study conducted by [14], investigate the effect of *Citrus limon* Essential Oil (CLEO) in situ against *L. monocytogenes*, as well as evaluated the physicochemical parameters (pH and TBARS) in minced beef meat model. They found that the CLEO was more effective against gram positive and negative bacteria at concentration varied from 0.039 to 1.25 mg/ml and 0.25 to 2.5 mg/ml respectively. Also, they assessed the CLEO as preservative substances in minced beef meet during storage at 4°C. The results showed that added 0.06 and 0.312 mg/g from CLEO were prohibit the contamination in pathogenic bacteria, particularly *L. monocytogenes*. Additionally, the values pf pH and TBARS were lower than those, which found in control meat. Ibrahim and Salem studied adding lemon grass and lime peel extracts (fresh and oil) to the prepared chicken patties during the storage for 9 days at 4°C, 0.25% of tested oil extracts ere an optimum concentration that have been effective against TBARS and lipid oxidation [15]. As well as, reduce the pH, aerobic plate count, mould and yeast in the treated chicken patties comparing the untreated (control). Additionally, the treated chicken patties were lower than in their content of Volatile Basic Nitrogen

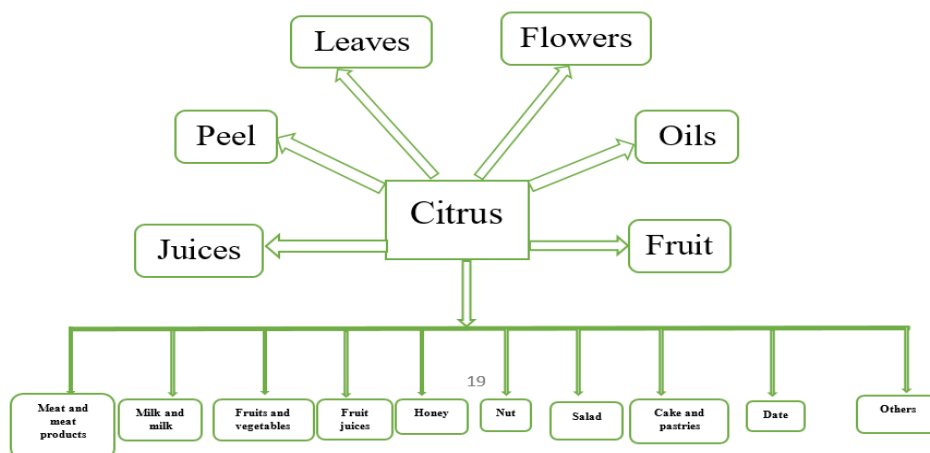


Figure 1:

(VBN) of control. On the other hand, they reported that addition the same concentration of lemo grass and lime peel extracts reduced the histamine, tyramine and putrescine formation in refrigerated chicken patties.

The extract of kinnow have been added as a source of antioxidant in salted chicken patties during storage. The results showed that the presence of salt alone improved the TBARS formation (114%), whereas adding both of the kinnow rind powder extract and salt at the same time led to reduced it to 90%. Also, the lipid oxidation was significantly reduced during the storage to 39% [16]. The effect of kinnow rind powder extract as a source of antioxidants in cooked goat's meat patties were investigated by Devatkal et al. [17]. The peel of citrus sinensis was dried and studied their effect on gastrointestinal microbiota and immune system of broiler chickens was conducted by Ebrahimi et al [18]. The results showed that the different amount of dried citrus sinensis peel was significantly affected on *Escherichia coli* in the caecum, but no effective in other microbial population that present in the gastrointestinal. Liu et al. studied the effect of combined of alginate-calcium and the extract from citrus wilsonii tanaka on microbiological and sensory change of white shrimps (*Litopenaeus vannamei*) during the storage at 4°C. They suggested that the methanol extract can be used as a new eco-friendly preservative that might use to increase the time of storage of shrimps and improve the quality.

Alfonzo et al., have been studied the effect of essential oil that extracted from lemon on the quality of salted sardines [20]. They found that the concentration of all microbial group under study were decreased during the entire period of monitoring. Also, the accumulation of histamine in sardines was decreased. On the contrast, the acceptability of sensory evaluation of sardines were observed higher than those of control due to their content of several volatile organic compounds. Fisher and Phillips reported that the citrus oils were more effective on the bacteria when we're adding to the cabbage leaf than on chicken skin [21]. Also, Tassou and Nychas found that the high effective for the essential oil were when they applied *in vitro* studies compared with in food system [22]. Furthermore, they noted that to obtain the similar effect such those *in vitro*, an increase in concentration of 10-fold, 50-fold and 25-100-fold have been used

in pork sausages, soap and cheese respectively, due to that there is a large of nutrients which available in food than in culture medium, since those nutrients enabling the cells to repair themselves. Smith-Palmer et al. suggested that the concentration required on salad and vegetables is less than that on high lipid foodstuffs [23]. The effect of orange and lemon extracts in cooked Swedish style meat balls was investigated by Fernández-López et al. [24], the rancidity-susceptible meat products have significant advantages.

After 24 hours of storage, bologna sausage sample that have been treated with the waste water (5-10%) obtained during the dietary fiber extraction from citrus exhibited to reduce the lipid oxidation and residual nitrite levels [25]. In another study, investigated the effect of three Essential Oils (EOs) have been extracted from orange peel (*Citrus aurantium L.*), lemon peel (*Citrus limonum L.*) and bergamot peel (*Citrus aurantium L.*), as antimicrobial and antioxidant in quality of sardine pilchardus. The results showed that the growth of inoculated *S. aureus* at a level of 3.5 log₁₀ cfu/g were reduced completely from second day until the end of storage at 8°C as a result of added the EOs from bergamot citrus peel at concentration 4×0.25-0.4 µL/ml. these result suggested that the EOs could be used as a potent natural preservative to improve the quality of sardines [26].

Milk and milk products

Kavas and Kavas, revealed that adding the orange Essential Oil (EO) to egg white protein powder as based film reduced the growth of microorganism in kashar cheese [27]. Thereby, extend the storage period than the film without EO. The phenolic compounds that present in EO inhibit the growth of pathogenic bacteria such as *S. aureus*, *L. monocytogenes* and *E. coli* O157:H7. In another study reported that using of citrus *aurantium L.* flowers (Bahararang Extract (BE)) as a source of antioxidant and antimicrobial at different concentration 500 to 2000 ppm to improve the quality and extend the storage period for traditional yoghurt stew. They found that the BE had strong effect on the growth of pathogenic bacteria (i.e. *Pseudomonas aeruginosa*, *Escherichia coli* O157:H7, *Bacillus cereus* and *Staphylococcus aureus*). Also, decreased the protein and lipid oxidation during storage [28].

Min et al. divulge that potentially use the acid hydrolysis extract from *Citrus unshiu* peel as a natural antimicrobial for low fat, whole

Table 1:

Types of Citrus	Type of Extracts	Parts	Applied in foods	Results	References
Citrus (kaffir lime, lime and pomelo)	Ethanol and Ethyl acetate	Peel	Stored raw chicken drumettes	More effective against pathogenic bacteria at level ranged from 0.4-50 mg/ml. The sensory properties have been increased than the control during the period of storage (14 days)	[13]
<i>Citrus limon</i>	extracts	essential oil	Minced beef meat	CLEO was more effective against gram positive and negative bacteria at concentration varied from 0.039 to 1.25 mg/ml and 0.25 to 2.5 mg/ml respectively. Adding 0.06 and 0.312 mg/g from CLEO were prohibit the contamination in pathogenic bacteria, particularly <i>L. monocytogenes</i> . The values of pH and TBARS were lower than those which found in control meat.	[14]
Lemon grass and lime peel	extracts	fresh and oil	chicken patties	The optimum concentration that have been effective against TBARS and lipid oxidation was 0.25% of tested oil extracts. Reduce the pH, aerobic plate count, mould and yeast.	[15]
Kinnow	extract	rind powder	salted chicken patties	Adding both of the kinnow rind powder extract and salt at the same time led to reduce the TBARS formation to 90%. Reducing the lipid oxidation during the storage to 39%.	[16]
<i>Citrus sinensis</i>	Powder	Peel	chickens	More significantly affected on <i>Escherichia coli</i> in the caecum.	[18]
<i>Citrus wilsonii tanaka</i>	methanol extract		white shrimps (<i>Litopenaeus vannamei</i>)	Increase the time of storage of shrimps. Improve the quality.	[19]
Lemon	extract	essential oil	salted sardines	Decrease the concentration microbial groups. Decrease the accumulation of histamine. The acceptability of sensory evaluation of sardines were observed higher than those of control.	[20]
Citrus		essential oil	pork sausages, soap and cheese	Increase the concentration of 10-fold, 50-fold and 25-100-fold that have been used in pork sausages, soap and cheese respectively, gave similar effect such those <i>in vitro</i> .	[22]
Orange and lemon	extract		cooked Swedish style meat balls	Enhance the rancidity-susceptible meat products.	[24]
Citrus	waste water	waste water (5-10%) obtained during the dietary fiber extraction	bologna sausage	Reduce the lipid oxidation and residual nitrite levels.	[25]
Orange peel (<i>Citrus aurantium L.</i>), lemon peel (<i>Citrus limonum L.</i>) and bergamot peel (<i>Citrus aurantium L.</i>)	extract	essential oils	Sardine pilchardus	Adding EOs from bergamot citrus peel at concentration $4 \times 0.25-0.4 \mu\text{L/ml}$ completely reduced the growth of inoculated <i>S. aureus</i> at a level of $3.5 \log_{10} \text{cfu/g}$.	[26]
Orange	extract	essential oil	kashar cheese	Extend the storage period. Inhibit the growth of pathogenic bacteria such as <i>S. aureus</i> , <i>L. monocytogenes</i> and <i>E. coli</i> o157:H7.	[27]
<i>Citrus aurantium L.</i>	Bahanarang extract (BE)	flowers	Traditional yoghurt stew	BE had strong effect on the growth of pathogenic bacteria (i.e. <i>Pseudomonas aeruginosa</i> , <i>Escherichia coli</i> o157:H7, <i>Bacillus cereus</i> and <i>Staphylococcus aureus</i>). Decrease the protein and lipid oxidation during storage.	[28]
<i>Citrus unshiu</i>	acid hydrolysis extract	peel	Low fat, whole and skim milk	Potentially using the acid hydrolysis extract from citrus peel as natural antimicrobial.	[29]
Citrus	extracts		milk	A combination of 75Mpa homogenization with either 150 ppm citrus extract or 0.12% vanillic acid, could be extend the shelf life by 4 days. Inhibit the growth all of <i>enterobacteria</i> , <i>Pseudomonas</i> and Lactic acid bacteria.	[30]
Bergamot (<i>Citrus bergamia</i>), lemon (<i>Citrus limonum</i>) and sweet orange (<i>Citrus sinensis</i>)	extract	essential oils	cabbage leaf and chicken skin	Showed antimicrobial effective against pathogenic bacteria, i.e. <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> o157:H7, <i>Bacillus cereus</i> , <i>Campylobacter jejuni</i> and <i>Listeria monocytogenes</i> .	[21]
Citrus of mandarin		wastes (both of peel and leaf)	Food grade kraft paper	The Water Vapor Permeability (WVP), Peroxide Value (PV) and air transmission for the treated papers were reduced than those in original papers. Possibility using the treated paper as food packaging and food coating to protect and extend the shelf life of food from deterioration that caused by moisture and oxygen.	[32]
<i>Citrus C. limon C. limonia C. latifolia and C. aurantifolia</i>	extract	essential oils	fruit fungal diseases	The MIC was effective against <i>B. cinerea</i> , in which the extracts from <i>C. limon</i> and <i>C. limonia</i> displayed $312 \mu\text{g/ml}$. whereas, the extracts from <i>C. latifolia</i> and <i>C. aurantifolia</i> were $625 \mu\text{g/ml}$.	[32]

Lemon grass	extract	essential oils	food spoiling yeast	Using thermal and lemon grass oil together have been showed a high preservative quality.	[33]
Citrus (lemon, biocitro and neroli)	extracts		apple juice	The MIC ranged from 160 to 500 ppm against two strains forming the spores (<i>Alicyclobacillus acidoterrestris</i>), when the biocitro and lemon extracts were used.	[34]
Citrus	lemon fruit	essential oil	apple juice	Adding 200 μ L of lemon EO combined with temperature of 54-60°C have been shown inactivation of <i>E. coli</i> O157:H7.	[35]
Citrus	extract		pineapple juice	Using of citrus extract and sodium-benzoate reduced the presence of spores (<i>Fusarium oxysporum</i>).	[36]
Lime		juice	honey and lime juice mixes	The antibacterial in the mixture have been affected against the bacteria that causes of cough (<i>S. aureus</i> and <i>S. pyogenes</i>).	[37]
Lemon juice citrus juice		juice	pistachio nuts	The heating treatment with 15 ml of lemon, 30 ml of water and 2.25 g of citric acid at 120°C for 1 h have been decreased the AFB1 level into 49.2%.	[38]
Citrus	extract	essential oil vapor	cucumber and lettuce	The <i>Enterococcus faecalis</i> and <i>Enterococcus faecium</i> , were reduced.	[7]
Lime	extract	essential oil	pastries and cream-filled cakes	MIC of the EO against the pathogenic were found 8 and 4 μ L/disc.	[39]
Citrus	extract	essential oils	dates	The citrus oils coated by chitosan inhibit the incidence of fungal decay at 12 days of storage on the average of 52-62%.	[40]
Orange peel sweet	extract	essential oils	food contact surfaces (plastic cutting board pieces and stainless steel)	The essential oil has been showed inactivate for <i>Vibrio parahaemolyticus</i> , <i>E. coli</i> and <i>Salmonella typhimurium</i> . Whereas no effect on <i>Staphylococcus aureus</i> , on the food contact surfaces.	[44]

and skim milk [29]. A study was conducted by [30] to explore investigate the combination of homogenization, citrus extracts and vanillic acid, to inhibit the growth all of *enterobacteria*, *Pseudomonas* and Lactic acid bacteria. The result highlighted that a combination of 75Mpa homogenization with either 150ppm citrus extract or 0.12% vanillic acid, could be extend the shelf life by 4 days in milk.

Fruits and vegetables

The Essential Oils (EOs) that extracted from bergamot (*Citrus bergamia*), lemon (*Citrus lemon*) and sweet orange (*Citrus sinensis*) have been showed antimicrobial effective against pathogenic bacteria, i.e. *Staphylococcus aureus*, *Escherichia coli* o157:H7, *Bacillus cereus*, *Campylobacter jejuni* and *Listeria monocytogenes*. In the food system, all the assessed bacteria were less susceptible in food system (cabbage leaf and chicken skin) comparing to their susceptibility *in vitro* [21]. In another study was conducted by Kasaii and Moosavi [31] to investigate the citrus wastes (both of peel and leaf of mandarin), and used it to treat food grade kraft paper. The result showed that the Water Vapor Permeability (WVP), Peroxide Value (PV) and air transmission for the treated papers were reduced than those in original papers. They concluded that a possibility using the citrus waste to treat the paper used it for food packaging and food coating to protect and extend the shelf life of food from deterioration that caused by moisture and oxygen. Simas et al. [32], studied the effect of essential oils that extracted from citrus against fruit fungal diseases. The results showed that the minimum inhibitory concentration was effective against *B. cinerea*, in which the extracts from *C. limon* and *C. limonia* displayed 312 μ g/ml. whereas, the extracts from *C. latifolia* and *C. aurantifolia* were 625 μ g/ml. The effect of lemon grass oil against several yeast that cause food spoiling was investigated by [33]. Both of lemon grass oil alone and a mixture of all oil and thermal treatment were applied in mixed fruit juices. The result showed that using the thermal and lemon grass oil together have been established a high preservative quality than using the individual exposure.

Fruit juices

Different type of citrus extracts (lemon, biocitro and neroli) investigated to their ability for the inhibition of the two strains forming the spores (*Alicyclobacillus acidoterrestris*). The results showed that the MIC ranged from 160 to 500ppm when the biocitro and lemon extracts were used; additionally, the using of thermal treatment at 80°C for 3-6 min enhanced their effect in apple juice and *in vitro* condition [34]. In another study conducted by Espina et al. [35], to investigated effect the combined treatment of thermal treatment and citrus fruit essential oil in apple juice to inactivate of *Escherichia coli* O157:H7. They observed that the adding 200 μ L of lemon EO combined with temperature of 54-60°C in the inactivation of *E. coli* O157:H7, might suppose a reduction in the treatment time and temperature (5.7 min and 4.5°C) respectively. [36], stated that the using of citrus extract and sodium-benzoate reduced the presence of spores (*Fusarium oxysporum*) in pineapple juice and improved the effect of homogenization in the same beverage.

Honey

The stability of antibacterial activity in the honey and lime juice mixes was conducted by [37]. The heating to 100°C for 15 min did not effect in antibacterial activity of the mixture. The antibacterial in the mixture have been affected against the bacteria that causes of cough (*S. aureus* and *S. pyogenes*).

Nut

The combined effect between lemon juice, citrus juice and heating was investigated in pistachio nuts to decrease of Aflatoxin B1 (AFB1). The result showed that the heating treatment with 15ml of lemon, 30ml of water and 2.25g of citric acid at 120°C for 1 h have been decreased the AFB1 level into 49.2% matching to their level before treatment, without altering in the physical properties of pistachios nuts [38].

Salad

Fisher K et al., divulge the effect of blend of citrus essential oil vapor against Vancomycin Susceptible (VSE) and Vancomycin Resistant (VRE), i.e. *Enterococcus faecalis* and *Enterococcus faecium*, on cucumber and lettuce [7]. The result display that the VSE and VRE strains were reduced comparing to their load before expose to the essential oil vapor. Also, they advised that using essential oil vapor as alternative to chemical antibacterial.

Cake and pastries

The effect of lime Essential Oil (EO) was studied against *Staphylococcus epidermidis* and *Bacillus subtilis* whose isolated from pastries and cream-filled cakes by [39]. MIC of the EO against the pathogenic were found 8 and 4 µL/disc. Also, they recommended that using of *citrus aurantifolia* EO in high concentration can improve the storage period for pastries and cream-filled cake.

Dates and others

The effect of different type of citrus Essential Oils (EO), combined with locust bean gum and chitosan on the *Aspergillus flavus* that caused postharvest spoilage in dates was conducted by [40]. They found that the citrus oils coated by chitosan inhibit the incidence of fungal decay at 12 days of storage on the average of 52-62%. [41], conducted the effect of Freeze Dried Citrus Peel (FDPCP) at different levels (5.55, 11.1 and 22.2 g/kg) during the storage periods of feed, comparing to feed treated with an Antifungal Agent (AA) at 0.05g/kg and the untreated feed. The results showed sign of adding FDPCP inhibit the deterioration and infection with aflatoxin over 21 days, whereas AA treatment and untreated were deteriorated after 16 days. In another study was conducted by [42], they stated that the effect of sweet lime peel oil and orange peel oil were lower than lemon peel oil in the inhibitory effect of food borne pathogens. Also, Ramadan et al. [43] assessed the effect methanol and ethanol peel extracts (orange, lemon and pomegranate) against food borne pathogens, which has been taken from rinsate of chicken skin. The results showed that the treated of skin chicken with 5mg/ml of the extracts gave significant reduction in food borne pathogens (Figure 1) [44], investigated the effect of essential oils extracted from orange peel sweet against some type of pathogenic bacteria, which were inoculated on the food contact surfaces (plastic cutting board pieces and stainless steel). They observed that the essential oil extracted from orange showed inactivate for *Vibrio parahaemolyticus*, *E. coli* and *Salmonella typhimurium*. Whereas no effect on *Staphylococcus aureus*, on the food contact surfaces.

Conclusion

A tale sort of bundling that consolidates dinners bundling substances with antimicrobial assets to control microbial floor pollution of fixings to upgrade item microbial wellbeing and to extend timeframe of realistic usability is pulling in leisure activity in the bundling business. In concurrence with the advanced pattern of offering cost to normal and sustainable assets, the utilization of natural antimicrobial mixes, exceptionally in sustenance and biomedical applications, will turn out to be extremely visit. The immediate expansion of common mixes to sustenance is the most regular methodology of utilization, regardless of whether severa endeavors have been settled on to find decision answers for the goal

of keeping away from bothersome inactivation. Plunging, showering, and covering treatment of suppers with enthusiastic alternatives are right now used to item preceding bundling as genuine choices.

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