Journal of Postharvest Technology
2022, **10**(2): 101-119
www.jpht.in

REVIEW ARTICLE

Phytochemical properties of biobased oils and their application for maintenance of citrus fruits quality

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Received: 27.2.2022 Accepted: 09.04.2022

ABSTRACT

Postharvest losses in citrus are often associated with excessive loss of moisture, poor cooling, and temperature abuse during harvest through to consumption. The incidence of decay from microorganisms can determine the quality of citrus and reduce the shelf life. At present there are consumer concerns regarding some pathogen's resistance to fungicides from synthetic sources. The cost involved in the application of fungicides makes it unprofitable for small scale producers and the retail sectors. An alternative preservative that can offer effective maintenance of citrus fruit quality during storage is needed. Therefore, this review summarises the functional properties of biobased oils and their application in the control of moisture loss, firmness, Total soluble solid, titratable acidity, pH, ascorbic acid and sensory properties of citrus fruits. It was established that there are some positive thrives on quality maintenance of citrus but antifungal activity of individual compounds in oils still require further research. Also several oils from seeds have been reported whilst biobased oils from plant leaves not extensively exploited. This review provides insight on beneficial effects of biobased oils on quality and shelf life of citrus fruits.

Keywords: Biobased oils, phytochemical, antimicrobial, postharvest quality, functional properties

Citation: Abdul-Rahaman, A. Irtwange, S.V. , Kortse, P. A., and Bashir, B. 2022. Phytochemical properties of biobased oils and their application for maintenance of citrus fruits quality: a review. *Journal of Postharvest Technology*, **10**(2): 101-119.

INTRODUCTION

Citrus group is considered one of the most popular fruits in the world and it takes third position after grapevines and apples (FAO, 2011). Consumers usually judge the quality of fruits on the basis of appearance and freshness at the time of purchase. There are many successful postharvest techniques such as controlled atmosphere, modified atmosphere packaging, plastic film packaging which have become standard practice, however edible coatings are extensively applied to maintain the quality of fresh fruits and vegetables (Bourtoom, 2008). Citrus fruit are non-climacteric, hence their respiration rate and ethylene production do not exhibit remarkable increase along with changes related to maturity and ripening as in climacteric fruits. However, although they have a relatively long shelf life compared to other tropical and sub-tropical fruits, they may experience physiological postharvest losses if they are not properly handled and stored. As with other horticultural products, major postharvest losses in citrus are caused by weight loss and physiological disorders (Palou et al., 2015). Postharvest peel pitting at non-chilling

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ISSN: 2348-4330

temperatures is a severe disorder that affects fruit from several citrus cultivars worldwide. Sudden changes from low to high Relative Humidity (RH) after harvest induced peel pitting in "Navelina"and "Navelate" oranges as well as Fallglo" tangerines.(Alfe et al., 2003) "Marsh" grapefruit (Alférez and Burns, 2004).The symptoms can vary from discoloured, dried out, and extensive collapse of the fruit rind to dehydration or wilting at the stem end where the rind is thinnest(Porat et al., 2004). According to Mukhopadhyay (2004), citrus fruits are susceptible to many diseases which are caused by pathogens such as fungi, bacteria, viruses, viroids, phytoplasmas, spiroplasmas and nematodes. Decay is one of the major factors that limit the storage life of citrus and fungal infections account for greater portion of losses in harvested fruits (Schirra et al., 2000). The major postharvest fungal diseases are green mould, blue mould, sour rot, grey mould, Alternaria rot and brown rot (Giudice, 2002).Essential oils(Eos) are volatile aromatic components, and mostly extracted from plant tissues through steam distillation or solvent-based extraction. They present strong antimicrobial and antioxidant properties with different mechanisms. As potential preservatives, essential oils such as Citrus reticulata Blanco essential oil(Tao et al., 2014) clove oil (Daniel et al., 2015) tea tree oil (Li et al., 2017) have attracted considerable interests in the food industry. Chemical composition of EOs obtained from the fruits was greatly influenced by the maturation stages (Jin et al., 2009). Additionally, variations of the EOs composition in many different fruits have been observed, depending on genetic and environmental factors as well as ontogeny and analytical methods (Gil et al., 2002; Huang et al., 2013; Msaada et al., 2009; Soares et al., 2007; Telci et al., 2009).

Maturation stages constitute an important factor influencing chemical composition and biological activities of the EOs extracted from fruits, vegetables and medicinal plants (Koşar et al., 2008; Kumara et al., 1985; Telci et al., 2009; Yildirim et al., 2004). Despite the fact that some work has been carried out on the application of biobased materials for coating, no evidence of the use of eucalyptus and peels from citrus has been reported and significant loss of fruits still recorded by fresh produce and retail sectors across the globe. Therefore, the Aim of this research is to review and summarise the effects of Bio-based oils on quality of citrus to offer low cost but efficient technology for storage and return on investment.

FUNCTIONAL PROPERTIES OF BIOBASED OILS

Biobased oils are the wide range of secondary metabolites in most cases possesses antimicrobial, allelopathic, antioxidant and regulatory environment. The oils are a complex mixture of a variety of chemicals, including hydrocarbons, alcohols, ketones, aldehydes and other compounds. Fungicidal activities of the oils have been shown in numerous experiments (Bahmani et al., 2015).The most important functional properties of edible films and coatings are edibility and biodegradability; migration, permeation, and barrier functions; as well as physical and mechanical protection. Such properties allow their use for food quality preservation and shelf-life extension. Furthermore, as carriers of active compounds that can be released in a controlled way, they can also provide anti-microbial activity and be applied for decay control and safety enhancement (Dhall, 2013; Lacroix and Vu, 2013; Valencia-Chamorro et al., 2011; Zhang et al., 2014).Edible coatings maintain food integrity and can protect coated food products against bruising, tissue damage and in general, physical injury caused by impact, pressure, vibrations, and other mechanical factors (Porat et al., 2004).

The citrus species are a potential source of variable oil which might be utilized for edible and other industrial application (Velázquez-Nuñez et al., 2013). Essential oils are broadly used as pharmaceutical components, in nutritious supplements and for cosmetic industry and aromatherapy. Specifically, the Citrus peels, commonly treated as agro-industrial waste, are a potential source of valuable secondary plant metabolites and essential oils (Versari et al., 2003). Previous studies have shown that essential oils have antifungal activity in vitro and when directly applied to the food (Barrera-Nechaet et al., 2008; Garcia et al., 2008). In particular, some single constituents such as carvacrol, γ-terpinène and p-cymene become more effective when they are combined together and act synergistically (Adebayo et al., 2013). On the other hand, p-cymene is efficient facilitator of the transport of carvacrol across cell wall components and the cytoplasmic membrane of pathogenic fungi. Thymol, eugenol and carvone are widely used in the control of several fungi, particularly those which contaminate various important economic crops (Elshafie et al., 2015).

Chemical and Physical properties of biobased oils

The biobased oil composition of various Eucalyptus species oils has been identified over the years. The chemical profile and components of biobased oils from eucalyptus leaves significantly indicate 1,8-cineole as the highest monoterpenes and limonene as the lowest for most species(Carson and Hammer, 2010). The dominant chemical compound of the eucalyptus biobased oil based on GC-MS analysis shows dominance of 1,8-cineole relative to other monoterpenes which include ketones, phenols and alcohols (Davari and Ezazi, 2017; Taylor et al., 2012). Several related research in recent times has identified the chemical properties of eucalyptus oils and their functions in reducing the effects of microorganisms. Chemical analysis with GC-MS showed the presence of chemical properties of terpinene, terpinol as the common constituents in all eucalyptus oil samples tested (Cimanga et al., 2002).

The chemical properties of biobased oils are extremely diverse in biological function and chemical structures. Quinones have been reported to produce effective cellular biochemistry for defense against bacteria and fungi. The isolation of coumarins, flavonoids and tannins are important phenolics that provide biochemical functions (Lopes et al., 2017; Schmid et al., 2000). Eucalyptus oils that have saponins with specific compounds diversity such as steroidal and triterpenoids show the most representative molecules in the oils (Vincken et al., 2007).

Citrus peels are part of the citrus fruits which contain higher levels of oils used for postharvest and medicinal purposes. The chemical properties and activities of the citrus peels oil relate to the structural configuration of the constituents and their functional groups. Several active constituents were identified from citrus peels such as α-terpinolene, β-pinene and limonene (Jirovetz et al., 2005). The chemical composition of biobased oils from citrus based on GC-MS analysis showed the presence of limonene, β-Pinene, sesquiterpenes, 1,8-cineol,βpinene and α-pinene that demonstrates the activity pattern with greater antioxidative properties.(Ben Hsouna et al., 2017; Tepe et al., 2004).

Other research work on chemical compositions of citrus peel oils reported that limonene was the main component, while c-terpinene was found as the major sesquiterpene hydrocarbons and linalool as main oxygenated monoterpenes hydrocarbons(Ndayishimiye et al., 2017). It was previously reported that citrus oils based on GC-MS analysis produced three major monoterpene hydrocarbon compounds which include non-volatile compounds, terpene hydrocarbons and oxygenated compounds with little contribution to fragrance but higher antimicrobial activity(Tyagi and Malik, 2011; Velázquez-Nuñez et al., 2013). Citrus essential oils were reported with active chemical properties, as well as several medicinal applications. These readily available essential oils continue to be useful in food preservation. The chemical analysis of citrus peels oils by GC-MS revealed that the class of compounds that were predominant include, Terpinolene, β-Pinene, α-Terpineol, Linalool, γ-Terpinene (Cavanagh and Wilkinson, 2002; Hou et al., 2019; Hyun et al., 2004; Yu et al., 2017).

The specific gravity of orange peels oil helps to determine the weight of the oil which describe the state of the purity and quality of the oil. A specific gravity of most citrus peels oils are reported to be less than one with the exception of oxygenated aromatic compounds but refractive index higher than one was reported (Fagodia et al., 2017). The physical properties of biobased oils for the specific gravity and the refractive indices fell within acceptable ranges with slight deviation from the appearance (Golmakani and Rezaei, 2008). The physical properties of biobased oils of the specific gravity, viscosity, appearance and the refractive indices were reported to be within acceptable levels (Anwar et al., 2008; Yilmaz and Güneşer, 2017). Several studies on the physical properties and their contribution to quality of citrus peels oils reported that producing stable physical particles were largely depended on the interfacial tension and viscosity of the oils (Xiao et al., 2016; Ying et al., 2018).

The physical properties such as the specific gravity and the refractive index of eucalyptus oils are required to assess the quality of oils obtained from the leaves. The values of these two physical parameters were reported in the literature for various countries with standards set for the parameters. The physical property assessment based on the refractive index value for oils from eucalyptus was reported to be above 1 but less than 1.5 (Boukhatem et al., 2014; Harkat-Madouri et al., 2015). Studies revealed a specific gravity of 0.919 for Eucalyptus globulus which was found within the acceptable standards (Zrira et al., 2004). However, a relative lower value 0.913 was reported by Harkat-Madouri et al. (2015).

Phytochemical components of biobased oils

Plant based preservatives derived from plant extracts such as phytochemicals and essential oils are used against fungal development in many fruits and vegetables after harvest. Alkaloids, steroids, tannins, flavonoids, saponins and glycosides are secondary metabolites with various biological activities and act in plant defense mechanisms. Flavonoids usually occur as glycosides and aglycones in plant tissue which have antioxidant properties and antimicrobial and insect repellent properties (Saxena et al., 2009). Flavonoids and their antimicrobial effect are useful as a food preservative to extend the shelf life and safety of foods. The majority of the research related to using Essential Oils have been traditionally used for a very long time but research related to its toxicity are quite scanty. Currently, there are only a few defined standardized checking protocols for accessing the potential toxicity of most Essential oils. Kumar and Sarkar (2018) suggested that one of the major factors which should be considered for risk valuation of Essential oils concentration is the bioactive compounds. The antioxidant activity of essential oil of Citrus sinensis epicarp has recently been highlighted and it was attributed to the presence of phenolic compound(Kamal et al., 2013). A lemon pulp and peel was found to be rich in phytochemical activity as shown by the comparison of the two plant material and the phyto-constituents of the peel were found to be more than that of the pulp fractions(Mathew et al., 2012). Tables 1and 2 shows the phytochemical components of lemon peels and Eucalyptus spp usually found in essential oils.

Table 1: Phytochemical composition of Citrus peel

Components	Results	Reference
Flavanoids	+	Kamal et al. (2013)
Tanins	-	Pathan et al. (2012)
Terpenoids	+	Kamal et al. (2013)
Alkaloids	+	Pathan et al. (2012)
Steroids	-	Pathan et al. (2012)
Phenols	+	Bhuiyan et al. (2019)
Saponins	-	Kamal et al. (2013)
Coumarin	+	Ramírez-Pelayo et al. (2019)
Anthroquinone	+	Bhuiyan et al. (2019)

Key: + = Present, – = Absent

Table 2: Phytochemical composition of Eucalyptus spp

Components	Results	Reference
Terpinenol	+	Hafsa et al. (2016)
Saponins	+	Kaur et al. (2019)
Alkaloids	-	Neelam et al. (2014)
Flavonoids	+	Neelam et al. (2014)
Tannins	+	Kaur et al. (2019)
Quinones	-	Kaur et al. (2019)
Steroids	+	Sani et al. (2014)
Phenols	+	Neelam et al. (2014)

Key: + = Present, – = Absent

APPLICATION TECHNIQUES

Biobased oils can perform antimicrobial, antioxidant or flavouring functions when applied to food. Extraction of oil from citrus peels could be achieved using single or combinations of techniques such as, physical peeling and hydrolisation, mechanical drying or solar drying before mechanical pressing The most important action of an essential oil is to minimize or even eliminate the presence of microorganisms or reduce the phenomenon of lipid oxidation. These oils can be added directly to the food, contained in a separate container or incorporated into the packaging material. The application of essential oils was found effective where different volumes of lemon peels oils at (50, 250 and 500 µL) were poured onto sterile gauze that had been previously glued to a package (Almela et al., 2014; Sarkhosh et al., 2018) .For multilayer, thickness and uniform coating, an appropriate method was described by Debeaufort and Voilley (2009) in which oils were distributed over the surface of fruits by means of nozzles to obtain uniform coating. In a related research, the dipping method was described as the most common method of coating which involves immersion, deposition and evaporation of solvent which ensures the dispersion processes support wetting substrates and their interaction with coating matrix (Andrade et al., 2012).

There are several procedure for coating fruits, such as brushing, spraying and dipping. It has been reported that, spraying with low with uniform coating, dipping technique, direct brushing that produce high encapsulation efficiency(Chaudhary et al., 2020; Ju et al., 2019; Tharanathan, 2003). The application of the coating to fruits for storage occurs after few minutes of drying, to ensure homogeneity in the thickness of the oil and solvent ratios. In addition to the method of coating, the concentration of the formulations of the oil is also significant aspect of essential oil. Dikbas et al.(2008) suggested an application technique such that selected orange fruits for the experiments were washed in water, dipped in ethanol (70 %) for 2 min, rinsed twice with double distilled sterile water (10 min each) and air-dried before oils was applied. Another application technique was reported where the harvested fruits were divided into four groups after being surface-disinfected with sodium hypochlorite (2%, w/v) for 3 min, air-dried, and precooled at 0°C for 12 h before coating (Passafiume et al., 2020; Xing et al., 2015). In a related study, Rojas-Grau et al.(suggested that 2% v/v of lemon, orange, mandarin and an emulsifier at 10% of volume oils dissolved in distilled water was effective in providing homogeneity. Different concentrations of oils that is evidence in the literature produce different results on the quality and shelf life of citrus during storage.

Fruit Decay

Edible coatings as wax, oils, natural products and others have been used as an effective technology to keep the quality of postharvest fruits and vegetables(Tietel et al., 2010). Most essential oil is known to contain more than 40% of phenolic compositions (thymol and carvacrol), that have strong antiseptics effect (Fatemi et al., 2011). Researchers are able to extract anti-microbial compositions from plants, and spray these on harvested crops to decrease decay (Fatemi et al., 2011). A related studies showed that the most essential oil in orange rind is limonin and was tested against 10 postharvest fungus disease agents which showed the most inhibition effect in spores germination and treatment showed inhibition effect in most fungi about 70 to 100% (Sharma and Tripathi, 2006). Inhibitory action can provide better protection against postharvest decay in fruits(Hassan et al., 2014). Based on investigation by du plooy (2009) it was shown that there is positive use of menthe and lemon essential oils on citrus green mould and essential oils are appropriate replacement for artificial fungicides. It was reported that, essential oil treatments in maintaining quality and reducing decay more was effective(Fatemi et al., 2011). Essential oils decreased decay of grapes and had antifungal activity of grape (Martínez-Romero et al., 2007; Romanazzi et al., 2009; Shiri et al., 2013; Tripathi et al., 2008). The application of essential oil as surface coating on fruit can maintain the quality of products and reduce the postharvest decay (Hassan et al., 2014). Thyme and clove essential oils completely inhibited P. digitatum growth either when added into the medium or by their volatiles per Petri dish. In in vitro mycelial growth assay showed fungi-static and fungicidal activity by clove and thyme essential oils. Sage and fennel oils did not show any inhibitory activity on this fungus(Yahyazadeh et al., 2008).Thyme and cinnamon essential oils are among the effective plant based oils used to reduce the incidence of green and blue moulds of citrus. Also, thyme oil was reported to control most postharvest citrus rots, such as green mould, blue mould and sour rot (Arras and Usai, 2001). It has been found that application of biobased oil coatings prevented the growth of pathogenic fungi and bacteria with no evidence of colonies responsible for the alteration of fruits during handling(Alfonzo et al., 2018; Passafiume et al., 2020). Many studies (Table 3) have captured the antifungal effects of plant essential oils against citrus fruit pathogens.

Table 3: Plant based oils used for the control of citrus postharvest diseases.

Plant material	oils	pathogen	Reference
Mentha arvensis	Plant based oil	*P. italicum*	Tripathi et al. (2004)
Zingiber officinale	Plant based oil	*P. italicum*	Tripathi et al. (2004)
Ocimum canum	Plant based oil	*P. italicum*	Tripathi et al. (2004)
Bubonium imbricatum	Plant based oil	*P. digitatum*	Dzamic et al. (2008)
Ageratum conyzoides	Plant based oil	*P. italicum*	Dixit et al. (1995)
Cinnamomum zeylanicum	Plant based oil	*Penicillium* spp	Kouassi et al. (2012)

Weight Loss of Citrus

Edible coatings provide a barrier against external elements and therefore increase shelf life (Guilbert et al., 1996) by reducing loss of water, flavour and solute migration. Essential oil had significant efficacy on weight loss of table grapefruit(Abdolahi et al., 2010). Edible coatings or edible films contributed to enhance the shelf life of fruits and vegetables by reduction of moisture loss solute migration and gas exchange; as well as by reducing the physiological disorders (Raghav et al., 2016). A minimum weight loss in oil treated fruits was reported to retard the process of transpiration and respiration by closing of lenticels and stomata of the cell wall of the fruits. The losses in fruit weight and moisture content of the peel are mainly due to fruit transpiration in which water moved out and results in wilted rind and a shriveled appearance. In related studies it was reported that coated fruit retained better glossiness and fresh appearance being a moisture barrier resulting in minimum weight loss in mandarin, know mandarin, Khasi mandarin and sweet orange (Mahajan et al., 2007). The evidence in literature demonstrated biobased oils application on fruits reduce the dehydration in fruits, maintain freshness index and maintained lower values of loss in weight relative to the untreated fruits during storage (Hu et al., 2015; Qu et al., 2020). Fruit shelf life and quality could greatly be influenced by surface coating with biobased oils during storage and established in the postharvest technology applications.

Total Soluble Solids (TSS)

Soluble Solids Content of stored fruits generally significantly increased with the extend of storage period, however, the treatment of fruits with essential oil produce lower contents of TSS during storage. The values of TSS of uncoated citrus fruits, both stored at 25°C and 5°C, were higher than those of coated ones (Davarynejad et al., 2013; El-anany et al., 2009; Sabir et al., 2004; Shahid and Abbasi, 2011). A gradual increase sugars of fruits treated with coating material can be justified by of coating material, acting as a barrier against loss of internal food value. The TSS values could be maintained over a reasonable period during storage of citrus by application biobased oils. A stability of TSS during storage after treatment with biobased oils has association with how conversion of reducing sugar is retarded. Metabolic activity could be reduced by the application biobsed oils resulting from reduced respiration rate when interaction of oils and plasma membrane of citrus fruits occurs. It was found in the literature that the application of the biobased oils to fruits induces higher TSS values resulting from rapid ripening and loss of moisture and the TSS content of stored fruits is determined by the protective barrier provided by the coating material(Das et al., 2021).

pH

In general, fruit acidity tends to decrease with maturation and increase in sugar content. Treated juice with fennel oil recorded significantly lower pH value different from (Mohammadi and Aminifard, 2013). Fruits coated with edible coatings showed significant delays in the changes of weight loss, decay incidence, acidity, pH and soluble solids, and ascorbic acid contents and maintained higher concentration of total phenolics and anthocyanins in comparison to control fruit (Gol et al., 2013). Fruits immersed at 200 ppb thyme essential oil had significantly higher pH than other treated or control sample(Rabiei et al., 2011). It has been reported that pH of fruits was considered important with least significance but due to the susceptible nature of bacterial organisms at lower pH to biobased oils is greatly increased resulting in faster dissolution in the lipids of the targeted organisms (Juven et al., 1994; Sánchez-González et al., 2011).

The determination of fruit quality characteristics based on pH is a significant method to demonstrate the length of shelf life or deterioration due to postharvest pathogenic organism. The pH values obtained during storage of citrus provides information on the possible micro-organism causing the deterioration of fruits in a non-acid or acid fruits. Yousuf (2020) found that most bacterial organisms causing spoilage are eliminated at lower pH during storage because they prefer close to neutral pH.

Firmness

Fruits firmness might be loss due to moisture loss from the fruits cells. The oil coated alone or in combination with other plant based oils can be efficient and make the fruits more intact and enhanced firmness. The firmness level of fruits might be due to coating material or in combination with other technologies that act as moisture and microbial inhibitor that reduces the respiration and transpiration of the fruits. Mahajan et al., (2007) reported that oil coated fruits reduced the moisture loss from the surface, thus maintain cell wall integrity and tissue rigidity. It mostly found that the firmness decreased with an increase in storage duration. The metabolic events responsible for textural changes leading to fruit softening during maturation and ripening of citrus fruits involve loss in turgor pressure, degradation and other physiological changes on the composition of membranes. Castillo et al.(found that although the mechanism involved in citrus softening is still unclear, the results reported could be attributed to higher turgor pressure in treated lemons, since lower weight losses and reduced softening were shown. Hong et al.(suggested that the treatment of fruits with essential oils could significantly control the loss of firmness and delay the changes in chlorophyll in fruits. This treatment could induce an increase in the activities of POD and inhibit the production of superoxide free radical in fruits. The coating material helps to provide protection for the fruits against physical damage resulting from mechanical forces and physical injury. The various examinations methods that addressed the strength of the coating material as a film for fruits such as burst strength and abrasion resistance has been reported (Dhall, 2013; Palou et al., 2015).

Titrable acidity (TA)

There are available reports that revealed the effects of different levels of treatments to the titrable acidity (TA) of citrus during storage. The TA changes as storage proceeds and decreased with the advancement of the storage period in most cases. The decreasing trend of acidity during the storage period could be due to utilization of acid in tricarboxylic acid cycle in respiration process. It was found that the TA was recorded maximum in the fruits treated with oil compared with control at the end of the storage (Adams et al., 2018; Rokaya et al., 2016). The higher acidity in the oil treated fruits was attributed to lesser utilization of the acids in the respiration process during the storage whereas untreated fruits had minimum acids was due to faster utilization of the acids in the respiration process during storage. Titratable acidity increased over the storage time for all the treatments. In a study conducted on the titrable acidity values of fruits, it was established that significant differences among the titratable acidity of different samples during the initial storage period was observed but becomes non-significant at the end of storage (Yousuf, 2020). A titrable acidity as an important quality parameter is used to determine the total concentration of acids in the fruits. The total concentration of acids in a sample fruits size and juice content are protected by the costing with essential oils that provides important information in establishing standards for storage and marketing purposes(Alcaide and Forner, 2003; Mohammed et al., 2021; Yu et al., 1995).

Ascorbic acid content

Several research have been conducted pertaining the effect of treatments using plant based oils on the vitamin C content during storage. Lee and Kader (2000) suggested that loss of vitamin C is caused by leaching in surrounding water and thermal breakdown on untreated fruits. The retention of vitamin C in the treated fruits is attributable to less degradation of the ascorbic acid in the storage resulting from the effective treatments. In related studies it was reported that ascorbic acid content was better managed for treated fruits than untreated for Knnow mandarin, Khasi mandarin, and Nagpur mandarin (Sonkar et al.,2009; Deka et al.,2006; Ladaniya et al., 2005).The determination of values for vitamin C can be an alternative for quality control citrus fruits as in the routine of physio-chemical characterization, the analysis of results show a wide range of values with a largest variations up to six fold, were observed in vitamin C among treatments (Nicola et al., 2014; Rodrigues et al., 2020).

Sensory properties

Quality is the most important factor in determining the market value of appearance. The application of surface coating on fruits is considered as one of several treatments developed to reduce postharvest losses and to prolong self-life of fruits (Hassan et al., 2014). Use of essential oil alone can cause adverse effects on fruit flavour and the sweetness of the fruit overshadowed, especially when used with a high concentration (Malihe et al., 2015). It has been reported that edible coating treatments increase volatile concentrations in fruits due to the formation of a semi-permeable barrier and leading to consumer acceptance (Olivas and Barbosa-Canovas, 2005). The use of a plant based oil treatment preserved the quality of fruits to the greatest extent(Dávila-Aviña et al., 2011) . Positive effects of coating were also observed in fruits treated with a coating of pectin and chitosan: coated fruit presented a better external appearance, a less dehydrated surface apparently without fungal growth and lower mass loss after 45 days of storage with high level of consumer acceptance (Medeiros et al., 2012). Fisk et al. (2008) found that coatings improved the surface appearance of fruit and fruits were well liked by consumers. Assessment of coated fruits sample as influenced by sensory evaluation has been reported with the suggested number of 10 panelist with broad knowledge in fruits physiological parameters and their degradation based on consumer acceptance (Benítez et al., 2013; Farina et al., 2017).

CONCLUSION

Biobased oils are well known for their functional and antifungal properties which are applied in single and in combination. These oils were found with the potential to extend the shelf life of citrus fruits during storage. The physiological parameters such as weight changes, firmness, Total soluble solids, titrable acidity, pH, ascorbic acid content and sensory all demonstrated positive response according to the literature studied. These readily available essential oils will undoubtedly continue to play important roles in the fresh produce sector. In the current review it was established that there are biobased oils from seeds and plant leaves with high biocontrol potential that have been made available only to few commercial farmers. It was also found higher concentrations of Phenolics, flavonoids, Tanin, Anthroquinone and Cumarin in the oils were responsible for effective control of fungal and bacterial pathogens. Research comprising the use of biobased oils extracted from plants waste and their compounds as reinforcement to act as hurdle for maintenance of quality and reduction of losses is greatly needed.

FUNDING

This study was funded by Centre for Food Technology and Research (CEFTER) the Africa Centre of Excellence for Control of Postharvest Losses at Benue State University, Nigeria.

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