Dynamic Agriculture: Problems and Way Forward

Volume - I

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Chapter - 22

Shellac: A Unique Gift of Nature

Priyanka Saikia, Purnima Das, Karishma Borah and Sarat Sekhar Bora

Abstract

The growing consumer appetite for fresh fruits and vegetables presents a pressing challenge to both researchers and the industry: how to innovate methods to uphold food quality and extend shelf life. Due to perishable nature of fruit and vegetables, it has a very short shelf life. Major losses in quality and quantity of fresh fruit occur by microorganisms, insects, pre and post harvesting conditions during transport and preservation (Mahajan *et al.,* 2018). The consumers around the globe also demand chemical free fresh fruits and vegetables with high quality, nutritional value and extended shelf life. So, in this modern era, the application of bio-based material as a way of enhancing the shelf life of highly perishable produce is promising. One of the important lipid derived biomolecule includes shellac. Shellac is the only natural resin of insect origin, *i.e.,* from a tiny insect *Kerria lacca* (Mohanasundaram *et al.*, 2016). It is a processed product of lac which is non-toxic, physiologically harmless and edible in nature. It is the shiniest coating available hence give a glossy appearance to fruits and vegetables increasing its marketability. Shellac based coatings prevent water loss, preventing shriveling, delaying ripening & senescence by decreasing the pectin methyl esterase activity which leads to reduction in softening of fruits and also reduces lipid peroxidation activity (Larrigaudiere *et al*., 2009). Shellac gain high demand for its extraordinary properties like it is thermoplastic, UV-resistant and shows excellent adhesion to wide variety of surfaces and possesses high gloss, hardness.Shellac is the only natural animal origin resin which have film forming ability. Shellac based coating is a very interesting field of study that could revolutionize the postharvest industry. These materials are biodegradable, ecofriendly and has less to no negative impact on the food product.

Introduction

Nature has given plenty of precious resources for the benefit of human beings, of which certain resources stand out for their versatility, cultural significance and historical importance. Among these treasures is lac, a natural resin secreted from the resinous glands of a tiny insect, *Kerria* spp. belonging to the order Hemiptera, super family Coccoidea and family Tachardiidae (Kerriidae) (Kumar *et al.* 2002; Pal, 2009 and Mohanta *et al.* 2014). This eco-friendly resin has played a multifaceted role in human civilization for centuries, embodying a unique symbiosis between nature and culture. The name "lac" comes from the Sanskrit word "laksha", which means "hundred thousand" that has given rise to the name lac, as thousands of insects are involved for its production (Thombare *et al*. 2022). From its origins in ancient traditions to its modern-day applications, lac continues to captivate and inspire with its myriad uses and profound impact on various aspects of human life.

The ancient significance of lac, as documented in the epic of Mahabharata and the Vedas, showcases its wide utility and lucrative nature. The "Lakshagriha" incident in the Mahabharata highlights its highly flammable property. The three Vedas-Yajur, Sam, and Atharva Vedas-believed to have been written between 1200-900 B.C., provide insights into the use of lac. The Kurukshetra War, dated around 950 B.C., preceded the Lakshagriha event, suggesting that the Atharva Veda may contain references to lac insects, making it one of the earliest documents mentioning them. This ancient wisdom illustrates the diverse application of lac in traditional medicine and its role in ancient societies.

In modern era, the scientific study of lac insect were first carried out by Father Tachard (1709), a Jesuit priest stationed in India, he first reported that a kind of “ant” on the branches of certain Indian trees left behind a secretion, which hardened on exposure to air and sun. However, James Kerr, a medical officer in the India Company’s Service, undertook a scientific study and published the paper entitled ‘Natural history of the insect which produces the gum lacca” in 1781. In 1790, William Roxburg, who is called as the ‘Father of Indian Botany’ studied Lac insects. First the name of lac insect, *Coccus lacca* was given by Kerr (1782), which was confirmed by Ratzeburi (1833) and Carter (1861). Afterwards, the lac insect was referred to as *Tachardia lacca* (kerr) by Green (1922) and Chatterjee (1915). Finally, the name was given as *Lacciferlacca* which is presently called as *Kerria lacca* (Reshma *et al*. 2018). In 1895, Emil Berliner, a German immigrant to the US, perfected the first shellac molded gramophone record, significantly boosting the demand for lac for nearly half a century. These records offered improved sound quality, durability and mass production capabilities compared to earlier recording technologies. However, gramophone records became obsolete by the 1980s with the rise of cassette players and DVDs.Whole world was dependent on India for this animal origin resin until synthetic resins gained prominence. But with growing preference for eco-friendly approaches, India is once again leading in the global lac market.

Lac insects, consisting of nine genera and approximately 100 species globally (Garcia Morales *et al*. 2016) with the *Kerria* genus alone comprising 29 species in Asia's tropical and subtropical regions (Varshney and Sharma, 2020). India commercially exploits 19 *Kerria* spp., notably *Kerria lacca*, *K. chinensis*, and *K. sharda* (Sharma *et al.* 2006). Among these, *K. lacca* has two sub-strains, Kusumi and Rangeeni, distinguished by host preference, life cycle, and lac quality. India being the largest producer, contributes 60-70% of the total world lac production. In the fiscal year 2018-19, India exported 8225.39 tons (valued Rs. 253.65 crores) of lac, followed by other Asian countries like Bangladesh, Myanmar, and Thailand, as well as China, Vietnam and Mexico. Lac production yields resin (65-70%), dye (1-2%), wax (4-6%), and insect/wood debris (25%) (Mohanasundaram *et al*. 2016). Lac insects are able to thrive on a wide range of ecosystem. It is already known that the lac insect thrives and draws nutrients from their hosts to complete their entire sedentary life cycle. Although lac insects grow well on Ber, Kusum, and Palas trees, they can be obtained on more than 400 different species of trees under 210 genera and 64 families (Sharma *et al.* 2006). Despite the abundance of host plants, lac cultivation remains limited due to a lack of awareness and suitable farming technologies among communities, restricting it to only a few native plant species. In Assam, they flourish on specific hosts like *Flemingia semialata*, *Flemingia macrophylla*, *Flemingia strobilifera*, Ber (*Ziziphus mauritiana*), Arahar (*Cajanus cajan*), *Leea* sp., Litchi, Kusum (*Schleichera oleosa*) and Palas (*Butea monosperma*). Cultivating lac sustains tribal livelihoods and also conserves biodiversity (Jaiswal *et al*. 2006).

Lac has versatile applications in various sectors, including inks, automotive, defense, and postal departments, as well as inslow-release lac-coated urea fertilizers,pharma sector or drug industry.Shellac is the processed lac and basically used in textile industries as stiffeners (e.g., hat and felt) in electrical industries for insulation, capping, lamination etc. of appliances, cosmetic industry and widely used as edible coating to enhance the shelf-life of fresh fruits and vegetables (Chen *et al.* 2003). This natural resin not only provides economic benefits but also serves as a sustainable alternative in various industries, contributing to the eco-friendly ethos.

Why Edible Coatings are Needed?

Presently, fresh fruit are most demanded in the market because of its good nutritional value. Due to perishable nature of fruit, it has a very short shelf life. Significant degradation in both the quality and quantity of fresh fruit happens due to various factors such as microorganisms, insects and conditions encountered both before and after harvesting, particularly during transportation and preservation. The utilization of bio-based materials, like edible coatings, indeed holds promise in mitigating these losses and extending the shelf life of fruits. Edible coatings offer a protective barrier and can mimic the effects of modified atmosphere storage by regulating the internal gas composition, thereby further enhancing preservation. The application of edible films and coatings to fruits and vegetables is an environment friendly approach to reduce or eliminate the risk of adulteration. By leveraging bio-based materials, we can not only address food waste but also meet consumer preferences for healthier and environmentally friendly options.

History of Edible Coating

In the early 12^{th} century, oranges and lemons were already being coated with wax to prolong their freshness. Similarly, during the 15th century in Japan, free-standing edible films made from soymilk were utilized for this purpose. By the 16th century in England, food products were coated with fat to prevent moisture loss. The practice continued to evolve over time. In the 1930s, hot-melt paraffin waxes were employed to coat citrus fruits in the United States. Then, in the 1950s, a combination of carnauba wax and oil-in-water emulsions became popular for coating fresh fruits and vegetables. From the 20th century onwards, edible films and coatings found diverse applications, including their use as casings for sausages and as chocolate coatings for nuts and fruits. This historical progression demonstrates the longstanding efforts to enhance the shelf life and quality of perishable food items through various coating methods.

Definition of Edible Coating

Any type of material used for enrobing (coating or wrapping) various food to extend shelf life of the product that may be eaten together with food is considered an edible film or coating. Coating makes barrier to moisture, oxygen & solute movement for the food thus enhancing the shelf-life. Importance of enrobing is to check processing quality, sensory quality and storage quality. Edible coatings derived from various sources are listed below.

Edible Coating				
Biomolecule based			**Plant derived**	**Nanoemulsion**
Polysaccharides	**Protein Derived**	**Lipid derived**	**Aloevera gel**	-
Starch	Corn-zein	Shellac	Herbal extracts	
Cellulose	Gluten & soy protein	Beewax	Natural volatiles	
Alginate			Essential oils	

Edible Coatings based on Biomolecules

Edible coatings can be prepared from biomolecules such as polysaccharides, proteins and lipids. These can either be applied as thin film to form wraps or pouches, or as coatings on food. The edible coatings approved by Food Safety and Standard Authority of India (FSSAI) are Shellac wax, Carnauba wax and Bees wax (FSSAI, 2011).

Lipid Derived Edible Coating

Lipids based coatings generally have good barrier properties against moisture, since it has very low affinity for water. Ediblelipids used to develop edible coatings are: beeswax, candelilla wax, carnauba wax, triglycerides, acetylated monoglycerides, fatty acids, fatty alcohols, and sucrose fatty acid esters. Lipid coatings and films are mainly used for their hydrophobic properties, representing a good barrier to moisture loss. This factor is extremely important as a large number of studies dealwith the use of coatings on fresh fruits and vegetables to control their desiccation. Besides preventing water loss, lipid-based coatings have been used to reduce respiration, thereby, extending shelf life and improving the appearance by generating a shine on fruits and vegetables. In contrast, the hydrophobic characteristics of lipids form thicker and more brittle films. Consequently, these must be associated with film forming agents such as proteins or cellulose derivatives. Coating sliced apples with a carbohydrate/lipid bilayer film reduced water edible coatings supplemented with citric acid acted as a gas barrier, decreased the respiration rate and delayed the browning of mango pieces during storage and consequently retained the carotenoids.

Shellac and its use

- Shellac is a natural gum resin which is non-toxic, physiologically harmless and edible in nature.
- Shellac is a hard, tough, amorphous, and brittle resin containing small amount of wax and a substance responsible for its characteristic pleasant odour.

- Its natural color is dependent on the type of seedlacand the refining process and can range from pale yellow to deep red.
- Shellac is insoluble in water, glycerol, hydrocarbon solvents and esters, but dissolves readily in alcohols and organic acids.
- Shellac is the shiniest coating available thus leading to glossy appearance and it prevent water loss thus preventing shriveling & increasing marketability.
- Shellac gain high demand for its extraordinary properties like it is thermoplastic, UV-resistant and shows excellent adhesion to wide variety of surfaces and possesses high gloss, hardness. Shellac is the only natural animal origin resin which have film forming ability.

Effect of Shellac-based Coating on Fruit Quality

Coatings	**Fruits**	**Results**	**Reference**
Shellac	Seeds & Fruits	Prevention of oxidation	Kajuo*et al.,* (2001)
Shellac	Plum	Increased lipid content & decreased weight loss. Firmness unaffected after short term storage at 20 °C.	Perez-Gago *et al.,* (2003)
Shellac, candelilla shellac-carnauba	Apple	Caused anaerobic respiration on Braeburn and Granny Smith apples. This research recommends shellac for "Delicious". Carnauba-shellac for "Braeburn" and "Fuji" Apples	Han *et al*., (2006)
Shellac + Aloe vera	Tomatoes	Improved permeability characteristics of the coating film towards oxygen and carbon dioxide and water vapour, delayed senescence.	Chauhan *et al*., 2015

Why Lac Formulation is Better?

Formulation does not stick to the conveyer belt of waxing plant and therefore does not require its regular cleaning. Unlike commercial formulations, lac-based formulation is operator's friendly, which means it, doesn't produce any obnoxious smell during operation of waxing plant. Spread area is better than the available commercial formulation (two tons of fruit can be coated by using only one litre of formulation). Since it is a water-based emulsion hence it can be used in pilot plant combining washing and wax treatment in one operation.

Advantages of Edible Coating Against Synthetic Coatings

1) Edible films and coatings act as barrier to gases and moisture that creates modified atmosphere within the fruit and which, in turn, extends the shelf life and retains the quality of fresh fruits and vegetables.
2) These also act as a barrier against microbial invasion and hence contribute towards hygiene.
3) Several active ingredients such as anti-browning agents, colorants, flavors, nutrients, spices can be incorporated into the polymer matrix and consumed along with the fruits, thus enhancing safety or even nutritional and sensory attributes.
4) The edible coatings help in the reduction of synthetic packaging waste, because of their biodegradable nature.
5) Because of the perishable nature of the fruits, the use of cold storage is necessary to delay changes related to ripening. However, cold storage often leads to the incidence of severe chilling injury symptoms. Therefore, appropriate post-harvest technologies with or without cold storage are needed of which use of edible coatings is an emerging strategy

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