Review on natural and synthetic edible waxes on vegetables and Fruits

K. Michael David, G.V. Ranga Reddy, S. Sunitha, B. Bhavani

Department of Botany, KVR Government College for Women (A), Kurnool, AP, India

Abstract: *After the harvest, fruits will rot fast and not have a shelf life because of pathogen attack. So, an edible wax coating, which is FSSAI approved, is added to increase its shelf life. If stringent quality control is imposed on the type of wax used, there is no reason to be alarmed when you see your apple or other fruits with a waxy coating. Waxes are esters of high molecular weight monohydroxy alcohols and high molecular weight carboxylic acids. They are chemically different from fats and oils, from hydrocarbon or paraffin waxes, and from synthetic waxes such as carbowax. Natural waxes are used in the food and cosmetic industries and have many other industrial applications.*

Keywords: *Edible Waxing, Cuticle, Plant waxes*

While health junkies prescribe planning our diet carefully, so that food works like medicine to heal your body, you are also assailed by messages on social media showing how our food is ‘poisoned’ with chemicals. And, if you thought the ‘‘an apple a day’ phrase offered same advice, there are videos showing how the apple we get from shops are much less attractive, once the layer of wax is scrapped off the skin.

Some fruits and vegetables have a natural waxy coating. After the harvest, fruits will rot fast and not have a shelf life because of pathogen attack. So, an edible wax coating, which is FSSAI approved, is added to increase its shelf life. If stringent quality control is imposed on the type of wax used, there is no reason to be alarmed when you see your apple or other fruits with a waxy coating.

Melvin Baby, a purchase manager with one of the biggest fruit suppliers in Kochi, says it is international regulation that fruits, such as apples and oranges, and even some vegetables such as potatoes and garlic are wax coated.

"When oranges are loaded, it will have the larvae of the Mediterranean fruit fly, for example. So, they must be washed before they are loaded. Large amounts of fruits are brush-washed mechanically, which causes them to lose their natural wax and so, they get coated with wax," he says, dispelling fears that paraffin wax is used as it is more expensive than edible wax.

The technology was first used in the US nearly 25 years ago, when orange orchards were destroyed by the attack of Egyptian fruit fly. One of the other reasons fruits were waxed were because of concerns about them being used as bio-weapons with the presence of anthrax. Research has been conducted into this for the past two decades and wax prevents the loss of water in apples and oranges. New types of edible wax are constantly being developed.

But even though the wax is edible, it is advisable to wash your fruits properly before eating them, Melvin says. Even though the fruits may not be directly touched from the time of loading, the transit time may be some days to months and dust gathers on the fruit by then.

The difference between Indian and US apples is the strict quality control; the former does not have grading and are not washed or sorted, while the latter are sorted accurately according to weight and quality. Apart from the US, apples to the State come from Italy, Belgium, New Zealand, Australia and Iran. Imported kiwis, grapes and strawberries also have a wax coating.

Dr Cyriac Philips, a leading hepatologist, says that in his discussions with nutritionists, he has found that waxed fruits do not have a negative impact on health. "The only problem is probably that the taste decreases a bit, but it doesn't cause disease. Wash fruits in lemon and vinegar to stay on the safe side," he says.

Fruit and vegetables are good sources of vitamins and minerals, including folate, vitamin C and potassium. They are excellent sources of dietary fibre, which can help to maintain a healthy gut and prevent constipation and other digestion problems. A diet high in fibre can also reduce your risk of bowel cancer. Fruits and vegetables can be classified as climacteric or non-climacteric. Climacteric fruit continue to ripen after harvest, whereas non-climacteric do not continue to ripen after harvest. Many important tropical fruits are climacteric, such as banana, mango, papaya, avocado, and guava. These fruit ripen rapidly during transit and storage, thus often requiring rapid shipment by air. There is an opportunity with climacteric fruit, however, to slow down ripening after harvest and thus, extend the shelf life. This can be done with controlled atmosphere (CA) storage, modified atmosphere packaging (MAP), or edible coatings. In all cases, the atmosphere created is relatively low oxygen (O_2) and high carbon dioxide (CO_2) compared to standard atmosphere. The low O_2 and high CO_2 depress ethylene production which is required to turn on ripening genes that affect color changes, aroma and degradation of cell walls resulting in softening.

MATERIALS USED IN EDIBLE COATINGS

Vegetable-derived waxes like Carnauba (classified as E903 additive with the EU references) and Candelilla wax (E902 additive), beeswax (E901), some micro crystalline and

paraffin waxes (E905) can be certified for human consumption (food grade wax), and some particularly high grade of waxes are also used in medical applications.

Waxing cheese started at least 100 years old, with red and orange for Gouda and Edam. Cheese wax is a food-grade wax, but contrarily to the fruit coating wax, cheese wax must be considered part of the cheese packaging and is not supposed to be eaten. This should be particularly evident with cheeses like Babybel, where a tear strip pops out of the wax casing. Modern cheese coating wax is designed to offer a great "unpacking" experience, cutting and separating easily from the cheese. Importantly, modern cheese wax allows to coat cheese in a huge variety of colors. Cheese is coated in wax to prevent mold growth, retain moisture… and to stand out

Some manufacturers actually mix chocolate and waxes. This seems to be more common in America and less popular in the EU. In both countries chocolate can be coated in wax to add shine and reduce melting

The crunchy coating agent that you break with the first bite of a spearmint gum is also made with Carnauba wax. If you search the web for the additive codes at the beginning of this post, you'll discover that wax is used in gummy bears too, and a range of other applications, including chocolate bars. Candelilla wax is also used in manufacturing chewing gum, while beeswax is also used in candies.

Waxes are now being used for waterproofing paper parchment typically used for waterproofing cheese packaging. An innovative use of wax that we are proud to work with is to waterproof reusable, sustainable cotton food wraps alternative to cling film.

In general, food grade waxes are used as glazing agents, release agents, stabilizers, texturizers for chewing gum base, carriers for food additives (including flavours and colours), clouding agents, emulsifiers, stabilizers, and thickeners

Edible coatings can be formulated from different materials including lipids, resins, polysaccharides, proteins, and synthetic polymers. Most of the coatings are a composite of more than one film-former with the addition of low molecular weight molecules such as polyols that serve as plasticizers. Surfactants, antifoaming agents, and emulsifiers are also often used in coatings. Lipid materials used in coatings are generally incorporated as waxes or oils. Carnauba, candelilla, and rice bran waxes are natural plant waxes; beeswax is also a natural product; and paraffin and polyethylene wax are petroleum based products.

Carbohydrate materials include cellulose, starch, and pectin which are plant derivatives; alginate, carrageenan and furcellarancome from seaweed and chitosan made from the exoskeleton of crustaceans. Gums including gum arabic, gum ghatti, gum karaya and gum

tragacanth are plant exudates; guar and locust bean gum are from seeds; and xanthan and gellan gum are products of microbial fermentation. Polysaccharides are not good barriers to water vapor, but exhibit moderately low permeability to gases and are useful to delay ripening of climacteric fruit.

Protein materials used in coatings include soy protein, corn protein (zein), casein and whey proteins from milk, wheat gluten and peanut protein. The wheat, milk and peanut proteins are potential allergens to a small portion of the population, which should be taken into consideration when formulating coatings. Zein can be used instead of shellac and as a group, protein materials are similar to carbohydrates in their permeability to water and gases.

Waxes

Waxes are esters of high molecular weight monohydroxy alcohols and high molecular weight carboxylic acids. They are chemically different from fats and oils, from hydrocarbon or paraffin waxes, and from synthetic waxes such as carbowax. Natural waxes are used in the food and cosmetic industries and have many other industrial applications.

Plant waxes are waterproofing components found on the outer surface of plants. They are the main barrier against environmental stress. Some of them have GRAS status (Generally Regarded As Safe) approved by FDA, which allows their use in foods. Plant waxes such as candelilla wax, carnauba wax, rice bran wax, sunflower wax, etc. with commercial and industrial importance are derived from different plants and used for the production of cosmetics, ink, varnish, polish, candles, crayons, etc. They are also used to obtain edible coatings for various food commodities. It was found that they maintain the properties and the quality of foods during their term of storage.

The main source of Carnauba wax (CW), sometimes called the “Queen of Waxes”, is the Brazilian palm tree (*Coernicia cerifera* Martius), also known as carnauba wax palm. The wax is found on the surface of the palm leaves. One of the unique characteristics of carnauba wax is that it contains long-chain alcohols and esters: unesterified alcohols (12%), x-hydroxy esters (14%), and esters of hydroxylated cinnamic acid (30%). Carnauba wax is one the hardest plant waxes, with melting temperatures ranging from 82.5 to 83 °C. Therefore, it is often used as a hardener to elevate the melting temperature of wax mixtures. Carnauba wax is the most commercially important plant wax. It has extensive applications in foods, confectionery coatings, cosmetics, automobiles, furniture wax, etc. and CW-based emulsions, edible coatings on fruits like fresh tomatoes, egg plant, Indian Jujube, sweet potaotes etc.

Candelilla wax, or the “Great Wax Rush”, is mainly obtained from the leaves of the plant *E. antisyphilitica* Zuccarini native to northern Mexican and southwest Texas. Unpurified candelilla wax contains approximately 42% hydrocarbons, 39% wax, resin, and sitosteroyl esters, 8% free wax and resin acids, 6% lactones, and 5% free wax and resin alcohol. Candelilla wax is an FDA-approved food additive used for glazing in certain foods. Microemulsions of candelilla wax are used as coatings with good gloss for fruits like Lemons, Strawberries, Golden delicious apples, Avocadoes, Pears etc.,

Rice bran wax is another high-melting vegetable wax found in rice husks (*O. sativa*). It is obtained as a by-product from the de-waxing of rice bran oil. The rice bran wax is a reddish brown, dark composite separated from rice bran oil and has good nutritional properties. It is separated from rice bran, which has several health-benefiting components. Rice bran wax (RBW) has been approved by the FDA as a safe food additive (21 CFR, 172.890). It has extensive applications due to its relatively low cost and abundance in Asia. It can be used as an efficient edible coating substance due to its excellent film-forming properties. The RBW has been effectively used in several food applications, such as forming oleogels, structured lipids, and edible coating of food products. Food applications include fruit and vegetable coatings, confectionery, and chewing gums.

Sunflower wax is found in the seed and seed hulls of sunflower (*H. annuus*). It is obtained through the winterization of sunflower oil. Like rice bran wax, it is a hard wax. Sunflower wax has not been approved for GRAS status by the FDA. Therefore, its applications are primarily in cosmetics, such as lipsticks, mascaras, lip balms, emulsions, etc. It functions as a consistency modifier and regulates the hardness, texture, and mold release of cosmetic formulations. It can also be used as a replacement for candelilla wax, carnauba wax, and rice bran wax.

The cuticle is synthesized in the epidermal cells of various plants, such as leaves, fruits, stems, and flowers, as a barrier between the plant surface and the environment. The cuticle is a hydrophobic layer composed of two lipophilic components, cuticular wax, and cutin. One of the most important functions of the cuticle is due to its hydrophobic component. Cuticular wax (obtained from the leaf/peel wastes of fresh fruit and vegetables, etc.) is a continuous layer outside or within the cuticle of plants. The presence of waxes on the leaf/fruit surface affects the degree of colorization, and the effect varies according to the plant species. Berry wax is isolated from the cuticle of different varieties of berry fruits. It is obtained from the peel berry wastes from the berry juice industry and is a potential source of natural waxes. Waxes find application in food packaging, cosmetic industries, coatings, etc.

Only the plant waxes approved by the FDA are used in the composition of wax coatings applied in the food industry. There is a high interest and a lot of research presenting wax coating with incorporated bioactive compounds

Waxes are used to modify the internal atmosphere and to reduce water losses of fruits and vegetables. Waxes are used only in tiny amounts. It may turn white on the surface of fruits or vegetables if they have been subjected to excessive heat and/or moisture. This whitening is safe and is similar to that of a candy bar that has been in the freezer. Commodities that may have coatings applied include apples, avocados, bell peppers, cantaloupes, cucumbers, eggplants, grapefruits, lemons, limes, melons, oranges, parsnips, passion fruit, peaches, pineapples, pumpkins, rutabagas, squash, sweet potatoes, tomatoes, turnips and yucca. The fruit waxing method can be manual or automated. During manufacturing, the waxy coating material is dispersed and dissolved in a solvent such as water, alcohol, a mixture of water and alcohol. Additives such as plasticizers, antimicrobial agents, minerals, vitamins, colors or flavours can be added in this process. The film solutions can be applied to fruits by several methods such as dipping, spraying, brushing and canning followed by drying.

Importance of waxing

1. To preserve fresh fruit quality during handling and subsequent marketing
2. To control storage atmospheric temperature
3. To extend the post harvest shelf life of fruit by reducing respiration and delaying senescence.

The principal advantages of wax application are

1. Improved appearance of fruit
2. Reduced moisture losses and retards wilting and shriveling during storage of fruits
3. Less spoilage specially due to chilling injury and browning
4. Creates diffusion barrier as a result of which it reduces the availability of O2 to the tissues thereby reducing respiration rate.
5. Protects fruits from micro-biological infection
6. Considered a cost-effective substitute in the reduction of spoilage when refrigerated storage is unaffordable
7. Wax coating is used as a carrier for sprout inhibitors, growth regulators and preservatives
8. Slow down the loss of volatile components from foods

Disadvantage

- High cost of the components and reduced economic efficiency
- No separate regulatory requirements for the use of edible coatings
- Development of off-flavour if not applied properly
- Adverse flavour changes for inhibition of O_2 and CO_2 exchange, thus resulting in anaerobic respiration
- Thus resulting in anaerobic respiration elevated ethanol and acetaldehyde contents

Types of waxes considering their texture

1. Solvent waxes: Solvent waxes widely used in citrus are composed of 70 to 80 % aliphatic Hydrocarbons and solvents such as acetone and ethyl acetate. The solvent will contain either a synthetic resin or a natural wood resin plus one or more plasticizers.

2. ***Water waxes:*** Water waxes are a second major type. The most extensively used are resin solution waxes and emulsion waxes. Resin solution waxes are simply solutions of one or more alkali–solube resin or resin-like materials such as shellac, natural gums or wood resins. Emulsion waxes are composed of a natural wax such as carnauba or paraffin or synthetic wax such as polyethylene emulsion

3. ***Paste or oil waxes:*** These are mainly composed of paraffins that are different in melting point and blended to give a desired viscosity. These are often used on vegetables

Categories of wax according to their use

1. **Storage wax**: when fruit is not to be marketed immediately
2. **Packout wax**: when fruits are to be marketed immediately
3. **High shine wax**: for giving a very high grace on market demand

Application methods

Manual rubbing: The process is performed by applying the wax coating over the fruit surface using a brush with soft bristles or absorbent cloth. After the application of edible wax, the fruits are air dried for about 15 min. It is a time consuming process and also requires manpower.

Dipping: The dipping method for fruit waxing is used when the fruits are coated with paraffin wax. The fruits are dipped in melted paraffin wax coat for about a second. The paraffin solidifies immediately on the fruit's surface after it is removed from the wax bath.

Brushing: This is an automated method of fruit waxing. The liquefied wax is dispensed over the brush that continuously applies a thin layer of wax coating over fruit surface. The wax can be sprayed using a pump through low-pressure nozzles.

Harmful effects of eating wax-coated fruits and vegetables

The fruit waxes are mixed with additives such as glycerols, lactic acid or acetic acid to adjust the pH of the coating material. In addition, the fruit waxes may also contain traces of preservatives, antimicrobial agents and texture enhancers. Morpholine is present in most fruit waxes to give thin and even films. The safe dose of morphine in humans is 4.3ng/kg body weight/day. Repetitive consumption of morpholine as well as some other chemical agents present in fruit waxing can be hazardous to health.

RISK OF CANCER

Morpholine is commonly used as a solvent and emulsifier in making wax coatings for fruits and vegetables. Morpholine by itself in the doses that are present in fruits and vegetables does not constitute a health risk. However inside the body when it comes in contact with nitrate, it forms Nitrosomorpholine (NMOR) a genotoxic carcinogen that poses a risk of liver or kidney cancer.

Risk of liver and kidney damage

Experts report that on oral and pareteral administration or after inhalation, morpholine is well absorbed and is distributed in the body fluids. Ingestion of morpholine through daily consumption of wax-coated fruits can affect liver and kidney function.

Allergies

Many edible coatings are made from ingredients that could cause allergic reactions. These allergens include protein substances such as soy, whey protein, casein and peanut proteins.

References

1. Sabka Pashova *Application of Plant Waxes in Edible Coatings* Coatings 2023, 13, 911
2. K. Michael David, Sapna B. and Akshata Sharma, Edible waxing on fruits and vegetables, Agri articles ISSN: 2582-9882
3. Bai, J.; Plotto, A.; Baldwin, E. *Edible Coatings and Films to Improve Food Quality*; Hagenmaier, R., Bai, J., Eds.; CRC Press: Boca Raton, FL, USA, 2011; pp. 185–242.
4. Maringgal, B.; Hashim, N.; Syafinaz, I.; Amin Tawakkal, M.; Tengku Muda Mohamed, M. Recent advance in edible coating and its effect on fresh/fresh-cut fruits quality. *Trends Food Sci. Technol.* **2020**, *96*, 253–267.

5. Nor, S.; Ding, P. Trends and advances in edible biopolymer coating for tropical fruit: A review. *Food Res. Int.* **2020**, *134*, 109208.
6. Fernández-Muñoz, R.; Heredia, A.; Domínguez, E. The role of cuticle in fruit shelf-life. *Curr. Opin. Biotechnol.* **2022**, *78*, 102802.
7. Martin, L.; Rose, J. There's more than one way to skin a fruit: Formation and functions of fruit cuticles. *J. Exp. Bot.* **2014**, *65*, 4639–4651.
8. Andréa Silva de Freitas, C.; Henrique Machado de Sousa, P.; Josino Soares, D.; Ytalo Gomes da Silva, J.; Rathinaraj Benjamin, S.; Izabel Florindo Guedes, M. Carnauba wax uses in food—A review. *Food Chem.* **2019**, *291*, 38–48.
9. Puttalingamma, V. Edible coatings of carnauba wax—A novel method for preservation and extending longevity of fruits and vegetables—A review. *Int. J. Food Saf.* **2014**, *16*, 1–5.
10. Pashova, S. *Application of Vegetable Waxes in Food Technology*; IK SAFO: Lovech, Bulgaria, 2011; pp. 147–148. [
11. ED European Parliament and Council Directive No95/2/EC 1995.
12. FDA. Food Additives Permitted for Direct Addition to Food for Human Consumption 21 CFR 172, Subpart C. Coatings, Films and Related Substances. 2006.
13. Guilbert, S.; Gontard, N. Edible and biodegradable food packaging. In *Foods and Packaging Materials—Chemical Interactions*; Ackermann, P., Jagerstad, M., Ohlsson, T., Eds.; The Royal Society of Chemistry: London, UK, 1995; pp. 159–168.
14. Nussinovitch, A. *Water Soluble Polymer Applications in Foods*; Blackwell Science: Oxford, UK, 2003.

*********.