International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 09 Issue 11 November 2026
DOI: 10.47191/ijcsrr/V9-i11-09, Impact Factor: 8.048
IJCSRR @ 2026
www.ijcsrr.org

Edible Coating on Almond and Walnuts Fruits

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ABSTRACT: Almonds and walnuts are nutritionally valuable nuts; however, their quality can deteriorate during storage due to moisture transfer, lipid oxidation, rancidity, and microbial growth. Edible coatings have attracted increasing attention as a potential approach to maintaining the quality and extending the shelf life of these products. This review aims to summarize recent research on edible coating materials and their applications in preserving the quality of almonds and walnuts. Relevant literature published from 2013 onward was searched using Google Scholar, Science Direct, and Scopus. Following the search and screening process described in the reviewed article, 35 articles addressing edible coatings for nuts were selected for information collection and analysis. The reviewed studies covered four main categories of coating materials: lipids, polysaccharides, proteins, and composite formulations, as well as emerging applications involving nanotechnology. The findings reported in the reviewed literature indicate that different edible coatings can help reduce moisture transfer, delay lipid oxidation and rancidity, limit microbial growth, and preserve the sensory characteristics of almonds and walnuts during storage. Polysaccharide-based coatings, including those containing chitosan, starch, and cellulose derivatives, were associated with improved quality preservation, while lipid-based coatings provided moisture-barrier properties. Protein-based and composite coatings also showed potential for maintaining sensory quality and reducing oxidative deterioration. Furthermore, studies involving Nano-enabled packaging reported improvements in shelf life and microbial control, although further investigation of nanoparticle migration and potential human-health effects is necessary. Overall, edible coatings represent a promising approach to improving the storage stability and quality of almonds and walnuts. However, their effectiveness depends on the coating formulation and storage conditions, highlighting the need for further research to optimize their application and assess their safety.

KEYWORDS: almonds, edible coatings, shelf life, walnuts.

INTRODUCTION

Almond, with the scientific name of (*Prunus Amygdalus*) is one of the dark rose plants belonging to dicotyledons. Almond is a tree native to West Asia, the southern shore of the Mediterranean Sea, and one of the oldest dried fruit trees. The plant grows well in hot and dry climates; the main area of almond production in the world is the central plains of California, and the second-largest area of almond production includes European countries along the Mediterranean (Farooq *et al*, 2021). Almonds have many benefits such as preventing heart disease due to their high content of oleic fatty acid-rich oil and other important nutrients. However, they are susceptible to oxidation reactions causing rancidity during storage. The aim of this work was to evaluate the chemical and sensory quality preservation of almonds coated with carboxymethyl cellulose and with the addition of natural and synthetic antioxidants during storage (Larrauri *et al*,2016). Walnuts (*Juglans regia*) are a nutritious food eaten worldwide, and are known for their sensory and healthy characteristics (Martınez et al, 2011). This dry-fruit is commonly used in bakery products, generally as a basic component of nut fillings in a range of confectionery products such as in the filling of chocolates, in cereal muesli mixtures and in other food products, including gourmet products (Lopez-Calleja and others 2015). Applied an edible coating on walnuts improves the sensory quality preservation keeping higher the intensity rating of walnut flavor and sweetness during storage and lower the intensity values of oxidized and cardboard flavors. The protective effect against sensory deterioration in walnuts was found to be more remarkable using the methyl cellulose coating (Antonella *et al*, 2016). However, carboxy methyl cellulose, methyl cellulose and whey protein edible coatings on walnuts helps to prolong the shelf-life of the kernels by preserving their chemical and physical quality properties. The use of methyl cellulose coating lessens the deterioration of walnut kernels (Grosso et al, 2018). edible coatings have been very important role the preservation quality and packing of fruits. some of them have an anti-fungal anti-bacterial characteristic, which are help with the shelf life of post harvested fruits (Larrauri *et al*,2016). Preservation is an important

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www.ijcsrr.org

link in the post-harvest management of fruits and vegetables, which affects the supply, shelf life, and prices of agricultural products as well as food quality and safety (Kun Li *et al*, 2022). the edible coating is an essential method for preservation of fruits and vegetables; it reduces the negative impact on agricultural products by regulating the oxygen, carbon dioxide, ethylene, temperature, microorganism growth, and pressure, thus enlarging the shelf life (Luangtana-anan *et al*, 2019). to improve the functional and technical properties of films and food coatings, certain materials can be used. Lipids and waxes are used in formulations to reduce water vapor permeability and formulations with polysaccharides are probably low hygroscopic, forming weak barriers to water vapor permeability, thus important in maintaining food quality (Martínez *et al*, 2020). edible coatings have a high capacity to transfer active ingredients, such as, for example, antimicrobial agents, anti-browning agents, colorants, as well as spices and nutrients. EO-absorbing coatings are useful for the use of EOs in food by increasing their distribution in food components (Jian Ju *et al*, 2018). the edible coating is defined as the thin layer of edible coating material, which is applied on food surface in liquid form. Some of its important functions are to protection the product from mechanical damage and chemical reaction as moisture barrier (Jian Ju *et al*, 2018). dry fruits specially almonds, walnuts and other are nutritionally important foods. These foods serve as a source of numerous bioactive compounds including provitamins, vitamins, minerals, antioxidants, and phytochemicals. The antioxidant, antibacterial, antifungal, antiviral, and anticarcinogenic properties of fruits and vegetables have been attributed to the presence of different phytochemicals (Yousuf *et al*, 2020). some type of material can be used for edible coating various food products to increase shelf life of the food product that may be eaten along with food with or without further removal of coating is considered as an edible film or coating (Akhtar *et al*, 2015). edible Coating materials can be either hydrophilic or hydrophobic; the main film-forming materials are biopolymers, such as proteins and polysaccharides (carbohydrates and gums); lipids and resins are also used this material applied can be alone or in combinations (Aguilera *et al*, 2012).

MATERIALS AND METHODS

Review design and information sources

The work was prepared as a literature review rather than an experimental study. According to the original article, Google Scholar, ScienceDirect, and Scopus were searched using the keywords “edible coating” and “dry fruits,” with almonds and walnuts specified as the products of interest. The stated search period was 2013 onward. After searching with these terms and examining the retrieved articles, the authors reported selecting 35 articles related to the use of edible coatings on dry fruits. The selected literature was used to collect information on coating materials, their intended functions, and reported effects on quality and shelf life.

Organization and information extraction

The extracted information was organized by coating-material category. The original article groups coating ingredients into proteins, polysaccharides, lipids, and composite materials; it also discusses polymer-based coatings and nano-enabled packaging as additional approaches. The present manuscript retains these categories and arranges the studies by material type and by the quality outcomes reported in the original source. The summary table includes the coating types and findings described in the source article, with citations retained where available.

Methodological limitations

The source article does not report the exact search date, complete database-specific search strings, duplicate-removal procedure, explicit inclusion and exclusion criteria, a screening flow diagram, or a formal appraisal of study quality. It also states that the search began in 2013 while citing some earlier studies, including work published in 1998, 2004, 2007, 2008, 2010, 2011, and 2012. Those earlier publications may have been used as background or may have been included in the narrative synthesis, but their selection status is not clarified. For these reasons, the review should be interpreted as a narrative summary of the source article rather than as a reproducible systematic review. No missing methodological details have been inferred or added.

RESULTS

Lipids in edible coating on Almonds and Walnuts.

Lipids are compounds that find in natural sources such as animals, insects, and plants. The diversity of the lipid functional groups is made up of phospholipids, phosphatide, mono-, di- and tri-glycerides, terpenes, cerebrosides, fatty alcohol, and fatty acids (Mohamed *et al*, 2020). Lipids are hydrophobic and water repellent. The hydrophobicity of lipids makes them excellent moisture

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barriers. In addition, coating of lipids also reduces the respiration rate of fruits and vegetables and improves the appearance by adding shine and gloss to the surface (Yousuf *et al*, 2020). general lipids which are applied in edible coating are waxes, acylglycerols, or fatty acids. Carnauba wax and beeswax are natural waxes that have been used to formulate coating for fresh-cut fruits, nut fruits and vegetables (Yousuf *et al*., 2018). Lipids edible coatings and edible film have many properties in the dry fruits, it provides gloss, reduce moisture loss, reduce cost, and complexity of packaging (Mohamed *et al*, 2020). the specific characteristics of lipid-containing edible coatings and films can be utilized for application in agriculture, food, and pharmaceutical industries (Yousuf *et al*, 2021). the palm fruits oil with favored water resistance, water vapor barrier, transparency, and elongation. These films can be used in nuts and fresh products for extending shelf life (Rodrigues *et al*, 2015). added ginger essential oil into HPMC coatings to be applied to almonds, and studied the oxygen permeability of the films in order to characterize the mechanisms that modulated the lipid oxidation protection (Chiralt *et al*, 2016). Quality Preservations of fruits are a huge or big trouble and challenge in the world nowadays. lipids edible coatings and films is a very best and impartment technique to resolve this trouble. It offers protecting edible overlaying or coating to dry fruits (Hassan *et al*, 2018). The using of hydrophobic components, for instance, oils into coatings and films in order to enhance the resistance against moisture in dry fruits such as walnuts, is one of the present strategies to prolong functional and mechanical properties of such edible coatings and films (Yousuf *et al*, 2021). The results show that lipid coatings have been proven to be effective in preserving walnut fruits and prolong the life of walnuts after harvesting at high temperature. the coatings on walnuts and pine nuts helped in limiting their oxidation and hydrolytic rancidity for 12-day storage at 25°C (Basharat *et al*, 2021). However, the studies show the carnauba wax edible coating can in dry fruits specially walnuts have a positive effect. edible coating of walnuts and pine nuts by whey protein isolate, pea starch, and carnauba wax reduced the oxidative and hydrolytic rancidity of the nuts and improved sensory characteristics (Mehyar *et al*, 2012). wax edible coatings are used commonly in fruit and vegetables to prolong their ripening period during storage, they are also applied to dry fruits products, nuts, almonds and a variety of other food items. Active packaging is yet another area of application of edible coatings (Kokoszka *et al*, 2007). however, the inhibition of lipid oxidation in coated walnuts, detected with a thio barbituric acid reactive substance assay, was reported as being associated with the low oxygen permeability of CW-based edible coatings, something that can improve the shelf life of similar food systems (Ledesma *et al*, 2022). edible coatings or films are a combination of polysaccharides, proteins, lipids, and plasticizers, used to enhance the functional properties and the general quality parameters of dry fruits such as texture, color, acidity, total soluble solids, thus preventing their browning and oxidation (aswini *et al*, 2022).

Poly saccharides in edible coating on Almonds and Walnuts.

the result show that the applied mastic gum edible coating has a positive effect in shelf life of almond. study indicated that mastic gum coating used in four different concentrations (0.5%, 1%, 1.5%, and 2% w/v) containing different bioactive compounds was effective significantly ($p < 0.05$) against moisture absorption and oxidative. reactions, total yeast and mold growth, and Aspergillus species development in peeled and coated fresh almonds, compared to uncoated fresh almonds as the control sample, during 4 months of storage, packed at room temperature (25–27 ◦C) inside a cabinet at90%humidity. By increasing the concentration of mastic gum, the protection against environmental factors during the storage period increased (Farooq et al, 2021). However, the utilized of mastic gum edible coating could be concluded that mastic gum coatings could be effectively utilized to extend the shelf life of peeled fresh almonds and other nuts such as walnuts, and the mastic gum as edible coating to maintain the quality of the product during storage. (Farooq et al, 2021). Polysaccharides are naturally occurring polymers, widely used to prepare edible films or coatings including starch, cellulose, pectin and derivatives of all these, pullulan, alginates and chitosan (Krochta et al, 1997). Polysaccharides-based coatings have been utilized for enhancing the shelf-life of several food products. High-fat food products such as nuts such as almonds and walnuts can be protected from oxidation with the aid of appropriate polysaccharide-based coatings. The most important polysaccharides used for this purpose include cellulose derivatives, chitosan, starch derivatives, alginate, carrageenan's, and pectin (Mostafavi et al, 2020). However, the chitosan based edible coating have a best result in nuts (almond and walnuts) fruits. Chitosan-based coatings have been widely used for enhancing the shelf-life of nuts (Sabaghi, M. et al, 2015). Edible coatings with hydrophobic character can prevent moisture absorption of nuts and help to maintain their crispiness during the storage. On the other hand, coatings with hydrophilic character can act as oxygen barriers which limit oil oxidation and fungal growth and also resist against lipid migration from nut surface. Chitosan cassava starch sodium alginate whey protein isolate and soy protein isolate have been recently used for this purpose (Mostafavi *et al*, 2020). Chitin and chitosan edible coating have been used in many applications, such as in fruits and other agricultural commodities to strengthen the mechanical properties, help maintain sensory

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IJCSRR @ 2026
www.ijcsrr.org

qualities of taste, color and avoid water loss (Rashaad *et al*., 2019). to increase their shelf-life. Or used as antimicrobial, it can also be used in meat products, like beef, to keep the color and avoid lipid oxidation during retail display. Or used in nuts for examples walnuts and other fruits (Ding, 2021). In general, the use of a cellulose edible coating on walnuts improves the sensory quality preservation keeping higher the intensity rating of walnut flavor and sweetness during storage and lower the intensity values of oxidized and cardboard flavor we can predict that walnuts coated with edible films like Methyl cellulose and stored for 365 d would have intensity scores for oxidized and walnut flavors of 17.25 and 73.37. methyl cellulose edible coated samples showed a better protection of walnuts against sensory deterioration. The other coatings (PS and CMC) also show a preservation effect on walnuts however this effect is lower compared to the methyl cellulose coating (Grosso *et al*, 2016). the utilization of rice based edible coating with additional functional ingredients is a successful strategy to extend the shelf life of walnut. The rice starch edible film alone and in combination with chitosan enhances shelf life significantly. In particular, rice starch edible films with 1% chitosan can extend the shelf life of walnuts more because of the improved coverage in the surface of walnut according to the SEM result at an accelerated temperature of 60 8C. Coated walnut products can be safely distributed or sold in tropical countries, which have a high RH and temperature. Furthermore, the application of starch-based coating for walnuts helps to reduce storage space as removing the husk and shell of walnuts results in less space requirements. Using the starch based edible films, the cost of storage can be reduced and the need for a refrigeration system can be eliminated. To the best of the authors' knowledge, this type of study is a first of its kind and the results are quite conclusive and important for the consumer as-well-as industry stakeholders (Aghazadeh et al, 2016). the results show that applied starch edible coating of Walnuts with 1% chitosan addition to the rice starch formulation, showed the lowest hardness, while walnuts coated with rice starch formulation showed the highest hardness during storage time (Aghazadeh et al, 2016). additives on walnut kernels at room temperature. It was shown that walnuts retain acceptable quality for 4 months with CMC based coating than pectin based one. Treatments included Vitamin E as an antioxidant with CMC based coating is low rancid and pectin-based coating showed more rancidity in walnut kernels (BASTANI *et al*, 2010). the inclusion of phenolic acids promoted the degradation of starch during the melt-blending and compression molding process, resulting in lower molar mass and shorter amylose branches. Our developed antioxidant starch films can be easily produced at low cost, they are edible and renewable, and they are excellent candidates as oxygen barrier in multi-layer packaging, with the possibility to replace synthetic coatings. Furthermore, the films incorporating rice straw extracts could be used as packaging to prolong the shelf life of food products like nuts such as almonds and walnuts or ready-to-serve fruit salads due to their antioxidant activity (Menzel et al, 2019). edible coatings may also be used to advantage on freeze-dried fruits like almonds and other nuts, in which moisture levels are reduced to very low levels. Coatings may be needed on these products to reduce absorption of moisture, reduce oxidation, or function as carriers for antioxidants or preservatives. (Elizabeth et al, 2013). Chopped nuts incorporated into premixed foods such as cake mixes require an edible coating to protect them from moisture absorption or reaction with other ingredients. However, carbonyl formation (a measure of off-flavor production) was reduced by 80% in a 15-month storage study by addition of the antioxidant TBHQ to the edible coating. BHA or BHT were also effective in prolonging the shelf life of roasted almond pieces when incorporated into commercial hydrogenated oils or acetylated monoglycerides (Elizabeth et al, 2013). when applied on walnuts, the walnut flour-based coating exerts protection against lipid deterioration, displays a marked effect on the preservation of walnut sensory properties and prevents the development of sensory attributes related to lipid deterioration. Furthermore, walnuts covered with WFC exhibit a similar consumer's acceptance when compared to the control sample and is preferred over the walnuts coated with MCC. Meanwhile, MCC presents similar or lower protection against most of the chemical indicators of lipid oxidation (Grosso et al, 2020).

Proteins edible coating on Almonds and Walnuts.

edible coating-based proteins can to prolonging and preservation a quality of dry fruits. Proteins have good adherence to hydrophilic surfaces and serve as good barriers against O2 and CO2. Edible coatings also have the potential for maintaining the quality of food after the packaging is opened by protecting against moisture change, oxygen uptake, and aroma loss (Lacroix et al, 2014). whey protein isolate (WPI)-based coatings and distilled acetylated monoglyceride (AMG)-based coatings were evaluated for their ability to delay the oxidative rancidity of walnut pieces. Tocopherol (Toco) and ascorbyl palmitate (AP) were added to improve the performance of the coatings (Mate et al, 1998). Protein-and carbohydrate-based edible films are generally more cohesive and flexible than wax films and possess better gas-barrier properties at certain conditions (Jooyandeh et al, 2011). On the other hand, Acetylated Monoglyceride coatings on walnut pieces resulted in increased shelf life. After 70 days, results indicated that the presence of both tocopherols and AP had a significantly positive effect on the performance of the AMG coating. The presence of citric acid

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IJCSRR @ 2026
www.ijcsrr.org

in the formulation of the AMG coating is likely to contribute to the positive effect of AMG coatings without antioxidants. With AMG coatings, walnut rancidity was delayed by supplying antioxidant agents to the surface. These experiments showed that by controlling lipid oxidation on the surface, where it is more active, rancidity of the whole nut could be successfully controlled (Juan I. Mate et al, 1998). Whey protein (WP) films and coatings have been designed to be coatings that lengthen shelf life, improve consumer acceptability, or raise the level of food safety for products like nuts such as walnuts, almonds and pistachio (Jooyandeh et al, 2011). Zein protein edible coatings were used as oxygen, lipid and moisture barriers for nuts such as (e.g., almonds, peanuts, walnuts), candies and confectionery products. These coatings are applied using ethanol as solvent, whose low surface energy allows good wettability and coverage of the hydrophobic nut surfaces. Zein-coated peanut bars and chocolate bars containing zein-coated nuts had increased shelf-life compared to products with uncoated nuts (e.g., almonds, peanuts, walnuts) (Garcia et al, 2010). whey protein isolate/acetylated monoglyceride coatings have also been applied as moisture barriers on chopped almonds. The nuts, which were then incorporated into ice cream, did not become soggy after 6 weeks of frozen storage. Uncoated, chopped almonds in ice cream became soggy after 1 week (García et al, 2010). the proteins edible coating or films could add a nutritional component to coated foods and would be useful for individual packaging of small portions of food such as peas, beans, nuts, and berries (e.g., almonds, peanuts, walnuts), (Baldwin et al, 1995). the results also indicate that the WPC coatings, regardless of composition or thickness, provided a glossy appearance that made the coated nuts like almonds, walnuts and pistachio very distinctive from the uncoated nuts. In addition, coated nuts like almonds, walnuts and pistachio were slightly darker (JAVANMARD, 2009). proteins Edible films and coatings add value to their products, increase shelf life and/or reduce packaging. Applications of interest to the food industry include: coating oxygen-sensitive foods such as nuts like almonds, walnuts and pistachio to extend shelf life and reduce packaging; coating nuts like almonds, walnuts and pistachio to prevent oil migration into surrounding food components (e.g., nuts in chocolate) (JAVANMARD, 2009). Corn zein proteins has been used in commercial coating formulations for shelled nuts like almonds, walnuts and others. The use of corn zein proteins as an edible coating or packaging film for prolonging of dry fruits been suggested (Swain et al, 2020).

Composite and polymer edible coating on Almonds and Walnuts.

In recent times, extensive research works from the edible ingredients discipline have focused on composite or multi aspect coatings to discover the complementary blessings of everything as well as to limit the dangers of these products. (Hassan et al, 2017). Composite substances can be received in both, bi-layers or emulsions. In composite coatings and films, lipid formulae the successive coating over the polysaccharide or protein layer. Studies have proved that the bi-layer films and coatings are generally tend to delaminate with the passage of time, develops cracks and pinholes. (Hassan et al, 2017). edible coating made of PS: WPI: CW (1: 1: 1) formed the most stable emulsions and homogenous film compared to the other coating formulations. All coatings were effective in preventing the oxidation and hydrolytic rancidity of walnuts and pine nuts. Among them, PS: WPI: CW (1: 1: 1 and 1: 1: 2) coatings were the most effective. The antioxidative activity of the coatings was also more efficient at the storage temperature of 25 ◦C than at 50 ◦C. Increasing the concentration of CW in the edible coatings reduced tensile strength and elongation of the coating material. The WPI: CW (1: 1) coating had the highest elastic modulus, but this was reduced with the addition of PS. All coated nuts provided positive sensory preference compared to the control, particularly, the PS: WPI: CW (1: 1: 1) formulation, which got the highest scores in smoothness, taste and overall acceptability in walnuts and peanuts (Mehyar et al, 2012). Polymer-based edible coatings attract significant interest due to their environmentally-safe properties and the possibility of application in the food packaging industry (Kokoszka et al, 2007). Dextrin's are applied to coat products such as nuts and almonds to preserve their organoleptic properties and texture in storage. Polymer edible coatings are used mainly in fruit and vegetables to prolong their ripening period during storage, they are also applied to coat meat products, such as almond, walnuts and other nuts, almonds and a variety of other food items. Active packaging is yet another area of application of edible coatings (Kokoszka et al, 2007). Chitosan is the deacetylate form of chitin, a biopolymer which can be extracted commercially from crabs and shell of shrimps and from microorganisms (yeast, fungus, and algae). the polymer chitosan edible coating has a positive effect on nuts such as almonds, peanuts walnuts and other nuts. In this study, chitosan was used as a packaging material for the quality preservation of nuts (cashew, almonds, peanuts nuts, and sunflower seed). utilization of polymer chitosan edible coating resulted to the control of fungi growth. of 2% chitosan on fungal growth of nuts stored at room temperature. Four samples of nuts were used (sunflower seeds, cashew, walnuts, peanut, walnuts, almonds) (Sidiq et al, 2019). Studies conducted on incorporating phenolic polymer edible films/coatings have a positive effect on walnuts. These compounds are effective in preserving the quality and shelf life of various food products. For

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Volume 09 Issue 11 November 2026
DOI: 10.47191/ijcsrr/V9-i11-09, Impact Factor: 8.048
IJCSRR @ 2026
www.ijcsrr.org

instance, coatings comprising chitosan and green tea extract containing phenolic compounds enriched with catechin, and epicatechin gallate prolongs the preservation of walnuts by delaying lipid oxidation and fungal growth (Sing et al, 2022).

Nano technology in edible coating on Almonds and Walnuts.

Nanoparticles that possess antimicrobial properties include some metals, such as Cu, Zn, Ti, and Ag. Among them, silver nanoparticles (Ag-NPs) deserve special attention as they exhibit the most effective biocidal activity against a wide range of microorganisms (Carbone, 2016). Nano packaging is currently one of the most important topics in food packaging technologies. The aim of the application of this technology in food packaging is increasing shelf life of foods by preventing internal and external corruption and microbial contaminations. Use of silver nanoparticles in food packaging has recently attracted much attention (Tavakoli et al, 2017). In summary, results of this study showed that using nano-silver significantly decreases molds, coliform and peroxide value in packaged samples. According to these results, longest shelf life obtained for pistachio, almond, hazelnut and walnut, respectively. While shelf life was 13 months for control sample, it was 20, 19 and 18 months for above nuts, respectively, representing a significant increase in the shelf life of treatment groups compared to the control groups. However, our results should be interpreted in the light of some considerations. Although the ability of silver nanoparticles to migrate from the packaging material into the food and its effect on human health is controversial (Rajeshkumar, et al, 2014). the possible introduction of silver in nut samples was not investigated in this study. Hence, extensive research about application of nano-silver in packaging and its effect on human health is recommended. There is thus a current need to study the relationships between particle characteristics, polymer type, food pH/polarity and environmental conditions relevant to food production, storage and packaging (*e.g.*, temperature, pressure, humidity, light exposure, storage time). Martirosyan, et al, 2014). moreover, using this packaging yielded an antioxidant effect especially when 2% and 3% nano-silver concentrations were used. Nano-silver also prevented growth of mold and so prevented aflatoxin production in all treatment groups. Results of chemical and biological tests showed that the silver nanoparticles had a significant effect on increasing the shelf life of nuts such as almonds, hazelnuts and walnuts. The highest shelf life belonged to pistachios, almonds, hazelnuts and walnuts with 20, 19, 18 and 18 months, respectively. The shelf life was associated with amount of silver nanoparticles (Tavakoli et al, 2017). although several previous studies have investigated the effect of nanoparticle coatings in reducing the number of total microbial count, none of them have studied the efficacy of nano-silver packaging in increasing the shelf-life and enhancing quality of nuts such as almonds, hazelnuts and walnuts. Hence, this study aimed to assess the effect of using nano-silver packaging on shelf life, microbial and mold load and also peroxide value of food during 24 months of storage (Tavakoli et al, 2017). Walnut kernels are widely used in human nutrition due to their high content of valuable components. the results show that the application of chitosan nano particles, nano composite chitosan and silver/ Ti nano particles edible coating in the prolongation of walnuts kernels have a best effect. properties occurred during ageing due to the action of environment parameters (air, water, temperature, light) and/orTiO2, which promoted degradation of cellulosic fibers and/or chitosan layer. Following the packaging of kernels in the investigated papers for 6 months at 25 C and 45% RH it was found that P–CH–Ag/TiO2 is the most effective in the prolongation of kernels shelf-life of walnuts (Cozmuta et al, 2018).

Summary of reported applications

Table 1 consolidates the principal coating types and outcomes reported in the original article. Because the source table includes studies with different products, coating formulations, storage conditions, and publication years, the entries are descriptive rather than directly comparable. Several rows concern almonds, while others concern walnuts or broader nut groups. Some entries are based on studies published before the stated 2013-onward search period, and this inconsistency is retained as a methodological point rather than silently resolved.

Table 1. Selected edible coating and packaging applications for almonds, walnuts, and related nut products.

Product or food	Coating / packaging type	Reported outcome in the source article	Reference as cited
Almonds and other nuts	Chitosan polymer coating	Reported control of fungal growth in nut and seed products.	Sidiq & Al-Nashi, 2019
Peeled fresh almonds	Mastic gum coating	Reported reductions in moisture absorption, oxidation, yeast/mold growth, and Aspergillus development during	Farooq et al., 2021

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		four months of storage; protection increased with concentration.	
Almonds	Chitosan and starch coating	Described as helping limit oil oxidation and fungal growth and resisting lipid migration.	Mostafavi et al., 2020
Nuts and other foods	Rice-straw-extract antioxidant starch film	Discussed as a renewable film with antioxidant activity and potential for extending food shelf life.	Menzel et al., 2019
Roasted almond pieces	Coatings with BHA, BHT, or TBHQ antioxidants	Reported to delay off-flavor-related carbonyl formation and extend storage life in the cited applications.	Elizabeth et al., 2013
Almonds, walnuts, pistachios	Whey-protein coating	Discussed as a possible means of extending shelf life and providing a glossy appearance.	Jooyandeh, 2011; Javanmard, 2009
Almonds, peanuts, walnuts	Zein protein coating	Used as a proposed oxygen, lipid, and moisture barrier for nuts in confectionery and other products.	García et al., 2010; Swain et al., 2020
Almonds, hazelnuts, walnuts and other nuts	Silver-nanoparticle packaging	Reported lower mold and coliform levels, lower peroxide value, and longer shelf life; migration into food was not assessed in the cited study.	Tavakoli et al., 2017
Walnuts	Polysaccharide-based coatings	Described as a potential approach for improving storage life and protecting quality.	Mostafavi et al., 2020
Walnuts and other agricultural products	Chitin and chitosan coatings	Reported potential to reduce water loss, improve sensory properties, and provide antimicrobial activity.	Ding, 2021; Rashaad et al., 2019
Walnuts	Methyl-cellulose coating	Reported higher walnut-flavor and sweetness ratings and lower oxidized/cardboard flavor ratings than comparison coatings.	Grosso et al., 2016
Walnuts	Rice-starch coating, including 1% chitosan formulation	Reported improved surface coverage and shelf-life outcomes under accelerated storage conditions; hardness differed by formulation.	Aghazadeh et al., 2016
Walnut kernels	CMC- and pectin-based coatings, including vitamin E	Walnuts reportedly retained acceptable quality for four months with CMC coating, with lower rancidity than the pectin-based treatment.	Bastani et al., 2010
Walnuts	Walnut-flour protein-based coating	Reported protection against lipid deterioration and preservation of sensory attributes; consumer acceptance was similar to control in the cited study.	Grosso et al., 2020
Walnut pieces	Whey protein isolate and acetylated monoglyceride coatings	Reported delayed rancidity; tocopherol and ascorbyl palmitate improved performance in the cited study.	Mate & Krochta, 1998
Walnuts and pine nuts	Pea starch + whey protein isolate + carnauba wax composite	Reported reduced oxidative and hydrolytic rancidity; 1:1:1 formulation had favorable film and sensory results.	Mehyar et al., 2012
Nuts and seeds	Chitosan coating at 2%	Reported control of fungal growth in the products examined.	Sidiq & Al-Nashi, 2019

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Walnuts	Chitosan and green-tea extract containing phenolic compounds	Discussed as a possible approach for delaying lipid oxidation and fungal growth.	Singh et al., 2022
Walnut kernels	Chitosan-coated paper containing TiO2 or Ag/TiO2 nanoparticles	P–CH–Ag/TiO2 packaging was reported as most effective among the tested papers after six months at 25 °C and 45% RH.	Cozmuta et al., 2018

CONCLUSION

Edible coatings have been long used empirically for food protection and shelf-life prolongation. The last few years have seen a growing interest in edible coatings. Almond, with the scientific name of (Prunus Amygdalus) is one of the dark rose plants belonging to dicotyledons. Almond is a tree native to West Asia, the southern shore of the Mediterranean Sea, and one of the oldest dried fruit trees. Walnuts (Juglans regia) are a nutritious food eaten worldwide, and are known for their sensory and healthy characteristics (Martınez et al, 2011). the edible coating is an essential method for preservation of fruits and vegetables; it reduces the negative impact on agricultural products by regulating the oxygen, carbon dioxide, ethylene, temperature, microorganism growth, and pressure, thus enlarging the shelf life (Luangtana-anan et al, 2019). Components or materials which are mostly used to synthesize the edible films or coating can be categorized into four classes: which include proteins, polysaccharides, lipids and composites. These materials are usually derived from plants and are eco-friendly and sustainable (Hassan et al, 2017). the palm fruits oil with favored water resistance, water vapor barrier, transparency, and elongation. These films can be used in nuts and fresh products for extending shelf life (Rodrigues et al, 2015). added ginger essential oil into HPMC coatings to be applied to almonds, and studied the oxygen permeability of the films in order to characterize the mechanisms that modulated the lipid oxidation protection (Chiralt et al, 2016). the utilized of mastic gum edible coating could be concluded that mastic gum coatings could be effectively utilized to extend the shelf life of peeled fresh almonds and other nuts such as walnuts, and the mastic gum as edible coating to maintain the quality of the product during storage. (Farooq et al, 2021). whey protein isolate (WPI)-based coatings and distilled acetylated monoglyceride (AMG)-based coatings were evaluated for their ability to delay the oxidative rancidity of walnut pieces. Tocopherol (Toco) and ascorbyl palmitate (AP) were added to improve the performance of the coatings (Mate et al, 1998). edible coating made of PS: WPI: CW (1: 1: 1) formed the most stable emulsions and homogenous film compared to the other coating formulations. All coatings were effective in preventing the oxidation and hydrolytic rancidity of walnuts and pine nuts. that using nano-silver significantly decreases molds, coliform and peroxide value in packaged samples. According to these results, longest shelf life obtained for pistachio, almond, hazelnut and walnut, respectively. While shelf life was 13 months for control sample, it was 20, 19 and 18 months for above nuts, respectively, representing a significant increase in the shelf life of treatment groups compared to the control groups.

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International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 09 Issue 11 November 2026
DOI: 10.47191/ijcsrr/V9-i11-09, Impact Factor: 8.048
IJCSRR @ 2026
www.ijcsrr.org

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ISSN: 2581-8341
Volume 09 Issue 11 November 2026
DOI: 10.47191/ijcsrr/V9-i11-09, Impact Factor: 8.048
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Cite this Article: Majidi, S., Sailzoi, A., Niazi, R., Majidi, A. (2026). Edible Coating on Almond and Walnuts Fruits. International Journal of Current Science Research and Review, 9(11), pp. 5601-5610. DOI: https://doi.org/10.47191/ijcsrr/V9-i11-09