ISSN: 2347-467X, Vol. 07, No. (3) 2019, Pg. 624-637

Current Research in Nutrition and Food Science

www.foodandnutritionjournal.org

Application of Edible and Biodegradable Starch-Based Films in Food Packaging: A Systematic Review and Meta-Analysis

JALAL SADEGHIZADEH-YAZDI[1]*, MASOUD HABIBI[2], ALI AKBAR KAMALI[2] and MAHDI BANAEI[2]

[1,3,4]Department of Food Sciences and Technology, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[2]Deputy for Food and Drug, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

Abstract

Background and Objective: In recent years, natural polymers such as starch have been widely considered as alternatives to plastics derived from petroleum derivatives in the production of packaging films. Currently, modified starches with new functional features are available that can be used in the production of the above mentioned films. The aim at this study is a systematic review and meta-analysis of application of edible and biodegradable starch-based films in food packaging.

Methods: At first all of the studies related to our title by using some keywords (edible and biodegradable starch-based films and food packaging) searched for English databases; Google, Google scholar, PubMed, Embase, CINAHL, PsycInfo, SCOPUS and ISI web of Science during the 2010 to 2018 was run consisting a predefined inclusion and exclusion factors. Inclusion and exclusion criteria were: papers related to edible and biodegradable starch-based films and food packaging, papers were English, types of papers were original and all the papers were free full text. As a result, related to inclusion and exclusion criteria papers were found and analyses. Data were collected based on study characteristics, edible and biodegradable starch-based films, food packaging.

Results: In the initial search, 589 articles were found that after reviewing the titles and abstract articles and removing repetitive and non-related, 33 possible related articles were examined. Of these, 24 articles were omitted from the abstract because of lack of access to the original article and lack of sufficient information. Finally, 13 papers were included in the study. Due to novel research on the application of bio-degradable biofilms

Article History

Received: 30 April 2019
Accepted: 11 September 2019

Keywords

Edible and Biodegradable Films;
Food Packaging;
Starch.

CONTACT Jalal Sadeghizadeh-Yazdi jsyazdy@yahoo.com Department of Food Sciences and Technology, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

Doi: http://dx.doi.org/10.12944/CRNFSJ.7.3.03

in the packaging industry of food, starch is one of the most promising and promising sources. Different needs in the food packaging industry for bio-films have led to the diverse sources of starch being studied, because each source has its own specific characteristics. The properties of films obtained from starch indicated the rigidity and reduced flexibility of the films. To prevent this and the corresponding effects on the film, other polymers can be used as additive compounds.

Conclusion: Extending the use of starch structure techniques and the use of this material in combination with other materials to reduce the inherent weaknesses of this natural polymer has led to its further development in various industries, especially packaged industries. Starch is a proper substitute for polymers extracted from oil derivatives. In order to improve the characteristics of the produced films, a high number of compounds can be added to the matrix, and various variations can be applied during the processing. Optimizing conditions will produce transparent, non-odorous, non-flavored, and color-free films with improved mechanical, optical and deterrent features.

Introduction

Today adequate and adequate food supplies have become one of the most important concerns of the authorities and community elites, in order to overcome many efforts in various areas, such as increasing production, increasing the amount of time consuming, improving Storage and storage practices, and developing methods for protecting them against destructive factors such as fungi and bacteria. The process of packing is important for keeping foods from fungi and bacteria and, finally, for long-term storage. In addition to other modern technologies that work in the food packaging industry, nanotechnology has become one of the most commonly used technologies in various fields in various fields.[1]

Recently, biodegradable food films have vital importance in food study, according to their reception to the condition and their use in the food packaging industry. Different sources of biopolymers can be applied as biodegradable films that consist of polysaccharides, proteins, and lipids.[2] Of the various varieties of polysaccharides, starch is particularly important according to its cheap price and its frequency in nature. Different factors influence the features of starch films, for example, the source from that starch is extracted, and the rather of starch composition.[3] Starchy films have benefits such as below thickness, flexibility, as well as clearness, but also, have a different weakness, consisting of weak mechanical features and its water vapor permeability. So, the application of starches only for the production of films restricts its use.[4] To increase the mechanical features of starch films, since enhancing its persistence to moisture, different ways can be applied, consisting starch repair ways, for example crosslinking and starch composition with various innate polymers.[5] The interesting to apply innate and renewable polymers in a different area is enhancing, that can substitute synthetic packaging films. Accordingly, starch is a famous material with a green sense. It considers bio-degradable, edible, and not rely on fossil sources and is broadly exist.

According to the enhancing need for biodegradable substance, it is exposed which these substances will be created in a more volume, so that starch will be applied in plastic films, sheets, and innate composite fibers, and eventually can substitute plastic foam.[6] Starch-based films have the appropriate physical features, so these films are odorless, taste-free, colorless and impervious to oxygen. So, there is a different limitation on the application of these films, for example, tense hydrophilic features (water sensitivity) and poor mechanical features than to customary synthetic polymers.[7] Starch is not an innate thermoplastic, so in the existence of the softeners at above temperature and below the shear power, it can melt and flow, therefore it can be throw in extruded thermoplastic polymers.[8] The study has revealed that starch has a proper film-making

impact; the starch source plays a vital role in film features according to the various ratio of amylose to amylopectin and the structural features of these macromolecules.[9] The study is searching for different to starchy sources which have good physical, chemical and functional features.[10] Ghanbarzadeh *et al.,* (2011) has shown various samples for use of this packaging substance for various foods and so has elaborated the various types of antimicrobial factor which may be incorporated in their formulations. Many agents are consisted of designing the antimicrobial packaging system. Most agents are nearly associated with the chemical features of antimicrobial factors, the innate of the substance and target microorganisms which all will be examined in this research.[11]

Basiak *et al.,* (2018) in a study found that the transfer properties of starch films containing 33% of plasticizer were less effective than film comprised of 50% glycerol. Water diffusivity, oxygen permeability, and water vapor permeability at two different humidity gradients, surface tension, works of surface adhesion and cohesion, and moisture sorption were tested. Glycerol content does not play a significant role on the color or mechanical properties. This work shows that glycerol can strongly affect the functional properties of starch-based coatings and films.[12]

Parreidt *et al.,* (2018) reviews the most recent essential information about alginate-based edible coatings. The categorization of alginate-based coatings/film in food packaging concept is formed gradually with the explanation of the most important titles. Emphasis will be placed on active ingredients incorporated into alginate-based formulations, edible coating/film application methods, research and development studies of coated food products and mass transfer and barrier characteristics of the alginate-based coatings/films. The summarized information presented in this article will enable researchers to thoroughly understand the fundamentals of the coating process and to develop alginate-based edible films and coatings more readily.[13]

Materials and Methods

In this study, a systematic review and meta-analysis of all researches conducted on determining the most important application of edible and biodegradable starch-based films in food packaging according to previous studies till 2018 was used. The method of presentation of data in this work, including the determination of the problem under study, data collection, analysis and interpretation of findings based on the systematic study reporting system i.e. PRISMA was done. The above-mentioned protocol as a criterion for searching the articles was used. There was a time limit for conducting electronic searches (2010-2018). To access the information requested from the studies related to our title by using some keywords (edible starch-based films, biodegradable starch-based films, and food packaging) searched for English databases; Google, Google Scholar, PubMed, Embase, CINAHL, PsycInfo, and Cochrane Database of Systematic Reviews. Inclusion and exclusion criteria were: papers related to edible and biodegradable starch-based films or food packaging, papers were English, types of papers were original and all the papers were free full text. In order to maximize the search comprehensiveness, the list of sources for all articles related to the subject was handled in a handy manner to find other possible sources. The main inclusion criterion of articles into this structured review was papers published in English that examined the application of edible and biodegradable starch-based films in food packaging. If there were multiple reports from a study, the most complete one would be chosen. In cases where the full text of the article was not available, the information in the abstract was used, and if the abstract of the article did not provide enough information, that article was excluded from the study. To select studies and extract data, the titles of all articles obtained by two of the contributors to the study and repetitive cases were first removed, then the title and abstract of the remaining articles were carefully studied and articles with no criteria for entering this structured review were deleted. Finally, the full text of the probably related articles was examined; eligible articles were selected and removed from the non-relevant items. As a result, related to inclusion and exclusion criteria 13 papers were found and analyses. Data were collected based on study characteristics, measures of edible and biodegradable starch-based films, and factors associated with food packaging. The PRISMA guidelines were followed in performing this systematic review.

To avoid subversion, extraction, and evaluation of the quality of articles was done by two independent researchers. If the articles were not submitted, the reasons for refusing it were mentioned. In cases where there was a controversy between the two researchers, the review was done by a third person. In the next step, the information about the selected articles includes the name of the first author, the year and place of the study, the year of the publication, the sample size, general characteristics of the samples, edible and biodegradable starch-based films, and the reported results in the study. The form has been pre-registered. For quantitative qualitative evaluation of articles, a systematic review of the choice bias (random sequence generation and allocation concealment) implementation (blindness of participants and evaluators), diagnosis (statistical analysis blindness), sample loss out of the study after randomization, and reporting (selective outcomes report). For this purpose, the risk of bias tool of the Cochrane collaboration group was used.

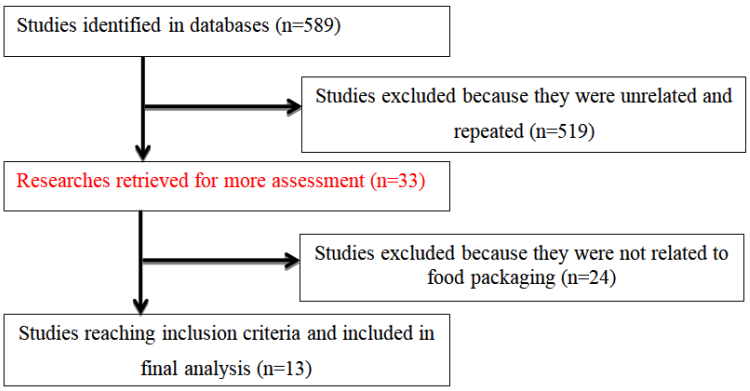

Fig. 1: The selection process of studies included in this study

We excluded studies according to inclusion criteria such as papers related to edible starch-based films, biodegradable starch-based films, and food packaging, papers were English, types of papers were original and all the papers were free full text that the information depicts on the Fig. 1.

Table 1: A summary of papers performed on the application of edible and biodegradable starch-based films in food packaging

No	Authors	Objectives	Materials and Methods:	Results	Conclusion
1	Molaee Aghaee *et al.,* (2015)[14]	Surveying the impact of packaging with chitosan film containing garlic basic oil on the chemical chicken filet amid capacity at refrigeration temperature.	Diverse levels of garlic basic oil (0, 0.5, 1 and 2%) were utilized in chitosan film arrangement. Chemical examination carried out in days 0, 2, 4, 7, 10, and 14 on chicken filets	Tests secured with distinctive films appeared lower values for pH, add up to unstable nitrogen (TVN), Thiobarbituric acid-reactive substances (TBARs), and peroxide list (P.V) compared with controls amid the think about ($p \leq 0.05$). By and	Chicken packaging with chitosan film particularly by particularly including different levels of garlic basic oil seem had a preventive impact on major chemical deterioration components. Considering the generally comparative preventive impact of 1 and 2 % basic oil levels conjointly financial angles, ideal dosage

			secured with distinctive films and put away at 4 °C. Factual investigation was carried out utilizing SPSS program.	large, a dose-dependent slant was watched by fundamental oil expansion.	for essential oil can be 1 % within the film.
2	Ghasemlou *et al.,* (2013)[15]	By including antimicrobial-antioxidants compounds, the plausibility of avoidance of pathogenic microorganisms will be given.	Composite eatable films based on corn starch distinctive concentrations of Zataria multiflora Boiss and Mentha pulegium (1,2,3%) were arranged by emulsification with the point of progressing obstruction and microbialproperties. Data were examined utilizing the SAS for Windows program.	The mechanical features were impacted by using using essential oils as tensile strength decreased and elongation enhanced mainly. SEM observation accepted the existence of essential oil in both the internal and surface parts of the films that elaborated reducing water barrier features of films covering lipidic compounds.	Discoveries appear that fundamental oil can have critical part in use of this film for nourishment innovation. In this manner, basic oil might be consolidated into these films for a few food-technology uses which require a moo fondness toward water.
3	Soukoulis *et al.,* (2016)[16]	The effect of the composi -tional, physico chemical and auxiliary properties of double starch -protein consumable films on Lactobacillus rhamnosus GG practicality and steadiness was assessed.	Local rice and corn starch, as well as bovine skin gelatine, sodium caseinate and soy protein concentrate were utilized for the creation of the probiotic eatable films. Starch and protein sort both affected the auxiliary, mechanical, optical and warm properties of the films, and the method misfortune of L. rhamnosus GG amid evaporation-dehydration was altogether lower within the nearness of proteins (0.91–1.07 log CFU/g) compared to exclusively starch based frameworks (1.71 log CFU/g).	In specific, a 3- to 7-fold increment within the practicality of L. rhamnosus GG was watched within the nearness of proteins, with sodium caseinate – rice starch based films advertising the foremost improved steadiness.	The film's shelf-life (as calculated utilizing the FAO /WHO (2011) premise of 6 log practical CFU/g) extended between 27-96 and 15–24 days for frameworks put away at ice chest or room temperature conditions individually.

4	Escamilla-García *et al.,* (2017)[17]	Examine the relationship between main and physical features of eatable films based on a blend of chitosan and altered starches.	Films were arranged by the casting strategy utilizing chitosan (CT), waxy (WS), oxidized (OS and acetylated (AS) corn starches and their blends. The CT-starches films appeared progressed boundary and mechanical properties as compared with those made from person components, CT-OS film displayed the least thickness (74 ± 7 μm), water substance (11.53% ± 0.85%, w/w), dissolvability (26.77% ± 1.40 % , w/v) and water vapor penetrability ((1.18 ± 0.48) × 10–9 g•s–1•m–1•Pa–1). This film appeared moo hardness (2.30 ± 0.19 MPa), moo surface harshness (Rq = 3.20 ± 0.41 nm) and was the foremost versatile (Young's modulus = 0.11 ± 0.06 GPa).	This was credited to intelligent between acetyl bunches of AS with the carbonyl and amino bunches of CT, clearing out CT with less positive charge. Interaction of the pyranose ring of OS with CT driven to expanded Goodness bunches that upon interaction with amino bunches, diminished the positive charge of CT, and this impact is capable for the diminished antimicrobial action.	It was shown that the sort of starch adjustment affected intelligent with chitosan, driving to diverse films features.
5	Wardana and Widyaningsih (2017)[18]	Create a bioindicator eatable films (BEF) from tapioca starch (TS), agar, and ruddy cabbage juice (RC), and to assess its execution on wiener weakening discovery.	The explore had a 3x3 randomized factorial experimental plan (agar: 3, 5, 7% by weight of TS; RC: 10, 15 , 20% v/v based on 100% of suspension). Glycerol was utilized as the plasticizer	The comes about appeared that the expansion of agar into the film solution expanded the thickness, stretching, and ductile quality, and diminished water vapor transmission rate (WVTR). Whereas the expansion of RC expanded the thickness, but diminished stretching, pliable quality, and WVTR. BEF comprising of 2% custard starch, 7% (w/w) agar and 10 % (v/v)	It seem distinguish an increment within the microbia l populace and within the pH varieties as result of wiener disintegration at 24, 48, and 72 h appeared through color changes of BEF from shinning purple at h to light purple, dim purple-blue, and purple-green color individually.

				RC was chosen to apply on frankfurter.	
6	Brandelero *et al.,* (2016)[19]	Assess the effectiveness of biodegr--adable films consisting starch/polyv--inyl liquor (PVOH)/ alginate with the expansion of main oil of copaiba (EOCP) or lemongrass (EOLM) compared to poly-vinyl chloride (PVC) films.	Lettuce examination cut into 1-cm strips were set in polyprop--ylene plate wrapped with biodegradable films and put away at 6 ± 2 °C for 8 days. PVC films were utilized as controls. The biofilms display--ed 11.43-8.11 MPa resistance and 11.3-13.22% stretc--hing, with water vapor porousness (WVP) of 0.5-4.04 x 10-12 g. s-1.Pa-1.m-1. The lettuce put away in PVC displayed minor add up to dissolvable solids (TSS), less glow (L), higher escalated of yellow color (b), and eight times less mass misfortune than that put away in biodeg--radable films.	Multivariate investigation appeared that the lettuce misplaced quality after 2 days of capacity in PVC films, speaking to a diverse result from the other medicines. Lettuce put away in biodegradab--le movies for 2 and 4 days appeared a more noteworthy likeness with recently collected lettuce (time zero).	The films with or without the adding of essential oil revealed same features. Bio--degradable films were created viable for the saved of minimally processed lettuce.
7	Javanmard (2010)[20]	poly-ethyleng--lycol (PEG), glycerol, and olive oil were joined into whey protein concentrate (WPC) by emulsification to create films.	Whey protein films were made using dispersing 10% whey protein concentrate in tap water and plastici--zed with various levels of glycerol, PEG or olive oil. The emulsion films were assessed for mechanical features, water vapor permeability (WVP) and opacity.	Expanding the levels of glycerol or PEG within the films brought about in a diminish in modulus and pliable quality. Expanding glycerol substance of the movies at oil/ protein proportions of 0.2 and 0.4 driven to slight increments in prolongation. Expanding the oil/protein proportion assist brought about in a diminish in prolongation for all films. No critical contrast in WVP and murkiness was watched between films made from blends of different	These results suggest that a whey protein based edible films is a viable alternative packaging process for food and improvement of shelf life.

				extents of whey protein concentrate-glycerol with expanding PEG (expansion) at all levels of the plasticizer.	
8	Gomes *et al.,* (2016)[21]	Develop and characterize edible films based on the starch phosphates of the seeds of S. burchelli, with the specific aim to apply these starches to cherry tomat--oes for post-harvest conservation.	The films were meas--ured for thickness, permeability to water vapor and solubility in water. The conse--rvation of cherry tomatoes with and without coverage was studied over 8 evaluation times (up--to 21 days) at 10±2 °C and 80±5% relative humidity. The edible films presented with an acceptable appea--rance and without the development of cracks. The concentr--ation of glycerol and the type of starch influenced the chara--cteristics of the films, increasing the perme--ability and reducing the water solubility of the various edible films.	The best result obtained regarding the conser--vation of cherry toma--toes was observed for fruits with edible coatings of greater permeability to water vapor; such fruits exhibited only a slight decline in firmness during storage compared with the control.	It can be concluded that the adjustment performed on the starch and the glycerol concentration emphatically affected the properties of the consumable films, permitting for ideal utilize in post-harvest uses.
9	Tabari (2018)[22]	Biodegradable film is broadly utilized since it is free from engineered substances and does not lead to enviro--nment conta--mination. This ponder pointed to get ready and characteriz biodegradable sago starch fi--lms stacked with Carboxy--methyl Cellulose na-	Sago starch films were arranged and plastici--zed with sorbitol/ glycerol by the casting strategy. Nano Carbo--xymethyl Cellulose with 0%, 1%, 2%, 3%, 4% and 5% (w/w) was included to the films some time recently casting them. The impacts of the expan--esion of nanoparticles were measured on mechanical features, water retention capacity, thickness and warm sealability.	In mechanical test of the combined films , by expanding of CMC nanoparticles concen--tration altogether ($P<0.05$) expanded malleable quality and Youthful Modulus and prolongation prameter appeared noteworthy ($P<0.05$) diminishment from 17.69 to 15.39. The seal quality for the sago film was expanded by consolidating a moo rate of nano Carboxymethyl	Considering biodegradability of the eatable films and enhancement of their mechanical properties by CMC nanoparticles, they can be utilized in several businesses, especially in nourishment industry, as an eatable coating for bundling nourishment and pharmaceutical items. With respect to its properties such as taken a toll sparing, biodegradability and mechanical properties when rate of CMC nanoparticles expanded can found a position among packaging materials.

		-noparticles.		Cellulose and upgraded the physicochemical properties and warm sealability of sago films.	
10	Adjouman *et al.,* (2017)[23]	Investigations the impact of glycerol, shelled nut oil and soybean lecithin on the water vapor porousness (WVP) of eatable films based on moved forward cassava (Manihot esculenta Crantz) local starches from Côte d'Ivoire.	The films were arranged utilizing 4 g cassava starch, 25% and 30% glycerol (w/w), 5% and 10% shelled nut oil (w/w) and 0% to 5% soybean lecithin (w/w oil) in Petri dishes. The WVP of the films was decided at 25°C and 75% relative mugginess. The damp--ness substance of the films was decided in an stove at 105°C and the film thickness was deci--ded physically employing a micrometer.	The coming about films was homoge--neous, straight for--ward and crack-free. WVP, dampness substance and thick--ness of the films expanded with expan--ding glycerol concen--tration. The combina--tion of glycerol and shelled nut oil expanded the WVP of the films, while expansion of soybean lecithin had no impact. The least WVP values were gotten utilizing 25% glycerol, 5% shelled nut oil and 5% soybean lecithin.	Starch gotten from moved forward cassava assortments developed in Côte d'Ivoire can be a potential fixing within the generation of nourishment bundling.
11	Rejak *et al.,* (2014)[24]	Assessing the water vapor permeability of starch films on the main of gravimetric way.	Permeability examinations were carried out for different material of raw substitute and processed at various screw speeds during film blowing.	Tests findings revealed that water vapor permeability amount extended from 2, 63.10-9 to 0, 65.10-9 g/ (m·s·Pa) rely on recipe of granulate and processing situation.	Lower permeability of water vapor take place in starch film with 20% of glycerol and 4% of poly (vinyl) alcohol processed at 80 rpm.
12	Xiaoyong *et al.,* (2018)[25]	Consumable iron yam and maize starch helpful nourishment flavoring packaging films with lemon fundamental oil as plasticization.	Lemon fundamental oil was utilized as plasticizers to get ready iron yam/maize starch consumable films. Changes of physical, microcosmic and antimicrobial features of films were examined.	Findings appeared that the expansion of lemon fundamental oil driven to diminish of dampness substance , straightforwardness, whiteness record, water vapor porousness, vapor porousness, solvency and malleable quality and the increment of b*, stretching and cloudiness values. With the increment of lemon	The iron yam/maize starch eatable films with great physical and antibacterial properties can be considered as helpful nourishment flavoring packaging materials.

			fundamental oil substance, the antibacterial movement expanded, and the surface and inner microstructure of the film got to be increasingly hetero--geneous.		
13	Doles *et al.,* (2014)[26]	Create a starch -based film bundling fabric with antimicrobial movement.	The foundation for the film is made of starch determined from custard. As a plasticizer we joined glycerol. The antimic--robial action was accomplished by including restorative plant extricates. The extricates of common restorative plants such as neem, betle leaves, guava leaves,rhizomes of lotus and turmeric, and blooms of hibiscus were utilized. The extricates were arranged utilizing ethanol extraction strategy.	The viability of extricates were tried by utilizing agar dissemination strategy. Five diverse bacterial strains such as *E.coli*, Pseudomonas, S. aureus, B. cereus and Klebsiella were utilized for the ponder.	Least inhibitory concentration and least bactericidal concentration values of extricates were too found out. We moreover conducted show nourishment considers for the film utilizing crude carrot and chicken.

Findings

In the initial search, 589 articles were found that after reviewing the titles and abstracts articles and removing repetitive and non-related, 33 possible related articles were examined. Of these, 24 articles were omitted from the abstract because of lack of access to the original article and lack of sufficient information. Finally, 13 papers were included in the study (Figure 1).

Edible and Biodegradable Films

These packages in the food industry can control or prevent the occurrence of reactions occurring within the package. Biodegradable packaging according to edible films has more importance due to the innate ingredients, the application of reincarnated and the deficiency of environmental pollution of the day to day. In this regard, the ability of such films as cover of antimicrobial and antioxidant factors and other active factors to increase quality, enhance the shelf-life, monitor of pathogens and increase the organoleptic features of the materials have different use for them in the food packaging industry.[27]

Application of Edible Films

Including applications of edible films, delaying the moisture content of food and the environment, controlling the amount of food breathing by reducing the amount of oxygen absorbed and selective blocking of CO_2 and vapor, reducing the migration of fats, maintaining the structure of food, including food additives, preventing the migration of aroma and flavoring and colored food products to the environment and between heterogeneous food components, preventing microbial corruption during long-term storage, increasing the nutritional value of the product, protecting the product against mechanical and physical damage, reducing the amount of packaging material and the complexity of packaging.[28]

Discussion

Food packaging is one of the important things that are done by different materials. Plastics over the last two decades, with annual growth of 5%, are the second most widely used materials for packaging food, paper, and paperboard. Oil-based plastic materials such as polyethylene, polypropylene, polyamide, despite the environmental problems, are used extensively for packaging due to its flexibility, transparency, and stability. However, despite good properties, their use and accumulation cause serious problems. Starch is a good alternative to petroleum-derived polymers due to its easy availability, food contact, low cost, and digestibility. However, the use of starch in packaging also has problems. For example, highly water-starch and its film properties are heavily dependent on moisture content and also have relatively poor mechanical properties. Its films are very fragile and resistant to oxygen permeation. In a study, the combination of PLA and starch with appropriate properties with suitable packaging properties was obtained and the results showed that different proportions of PLA-starch, (20-80 or 30-70) with epoxy soybean oil or malic a hydric, mechanical resistance, provides a very good prevention of water vapor and gases as well as good flexibility.[29] Khan *et al.,* used thermoplastic material due to their intermolecular forces and hydrogen bonding starches, called thermoplastic starches (TPS), which increases the flexibility of starch, causing the stability of starch is below its degradation temperature. TPS is a very promising product for biodegradable plastics than biodegradable plastics.[30] Corn starch was applied as a polymer matrix for the increment of antimicrobial packaging applying the way of casting and applies of Pittides Nisin or Pediocin to preserve food. Halloysite nanoparticles were selected to enhance the film. The results showed that the adding of Nisin and Piodosine peptides in starch films to the creation of active packaging substances with antimicrobial activity against L. Monocytogenes and C. Perforation.[31] Biodegradable starch/clay nanocomposite films were also used to pack foods. Montmorillonite nanomaterials (homogeneously distributed in various starch-based substances) were obtained by polymer melt processing methods. The structural and mechanical features of nanocomposite films were examined and the findings of the clay particle increase impact on the modulus and the starch strength revealed starch.[32] Starch and starch derivatives, Polyhydroxylbutyrate (polylactic glycolide), have high properties that are compatible with antimicrobial agents for packaging. PHB, starch, and PLGA have unique properties in the fields of food, cosmetics, pharmaceuticals as well as various composites. Starchy films were mixed with chitosan and potassium sorbate compounds and active films used to inhibit *E. coli* growth and S Aureus, as well as the deterrence properties of the films.[33] An environmentally friendly biodegradable nanocomposite was made using potato starch and pineapple leaves. Due to the fiber structure and the dispersion of nanofibers on the starch field, the properties of nanocomposites increase after reinforcement to 3% by weight of cellulosic nanofibers, but in loading more filler, these properties are likely to decrease due to the density of nanofiber. The permeability of water vapor, water absorption and absorption of moisture nanocomposites were investigated and it was found that the inhibitory properties increased significantly. The good dispersion and good adhesion of nanofibers to starch is the same structure of polysaccharides in both phases.[34] Jang *et al.,* (2017) prepared silver and starch nanoparticles for one-stage coating using ultrasound and a mixture of starch, silver nitrate and distilled water, which used starch as an environmentally friendly and inexpensive agent. Ultraviolet-neomorphic and transient electron microscopy showed that the single-phase process was effective for the synthesis of starch-coated coatings with silver nanoparticles.[35] Jang *et al.,* (2018) used synthetic zirconium and silver nanoparticles and starch (chitosan: starch-silver nanoparticle) for antimicrobial coating applications. Besides, the effects of different ratios of chitosan and silver nanoparticles and starches were studied on different study features such as mechanical features, water and oil opposition, and antimicrobial function. The findings revealed which the study covering features rely severely on the compound of these three substances, and then covering with a ratio of 1 to 9 shown good mechanical features and excellent resistance features to water and oil.[36]

Conclusion

Contaminants from petroleum-based polymer materials have focused on the production of biodegradable polymers. The global trend of

research and industry development is towards the use of biomass and renewable and environmentally friendly materials. Starch is one of the most abundant and cheapest substitutes for petroleum products and is now considered by researchers. Extending the use of starch structure techniques and the use of this material in combination with other materials to reduce the inherent weaknesses of this natural polymer has led to its further development in various industries, specially packaged industries. It is expected that in Iran, taking advantage of global experience, the production and use of starch will be developed as an important raw material in various industrial sectors. Due to novel research on the application of bio-degradable biofilms in the packaging industry of food, starch is one of the most promising and promising sources. Different needs in the food packaging industry for bio-films have led to the diverse sources of starch being studied because each source has its specific characteristics. While various starch components themselves are effective on the characteristics of the film, they produce different behavioral characteristics. To adapt the starch to create an interesting film, it can be revised by applying different substances. It creates films with interesting features, is free from improper chemicals during the film. Another new approach to improving the mechanical features and starch permeability is the application of different polymers with starch in film process that has the main impact on the improvement of the features of starch-based films; it may also have other features, such as antimicrobial features. The many novel studies on starch composite films are the use of bio-nano-composites that can have a good impact on the features of these films.

Acknowledgement

The authors would like to thank all of the people and persons for helping this study.

Funding

Given that our country is developing, the authors do not have the financial means to pay for it, and it is apparent that this article will be published for free.

Conflict of Interest

The authors declared that there is no conflict of interest.

References

1. Dimitrijevic, M., *et al.,* (2015). Safety aspects of nanotechnology applications in food packaging." *Procedia Food Science*. 2015; 5(1): 57-61.
2. Nasreddine Benbettaïeb, Frédéric Debeaufort & Thomas Karbowiak (2018). Bioactive edible films for food applications: mechanisms of antimicrobial and antioxidant activity. *Critical Reviews in Food Science and Nutrition.* 2018; DOI: 10.1080/10408398.2018.1494132
3. Bertuzzi M.A., Castro Vidaurre E.F., Armada M., Gottifredi J.C (2007). Water vapor permeability of edible starch based films. *Journal of Food Engineering.* 2007; 80(3): 972–978.
4. Elgadir M.A., Akanda M.J.H., Ferdosh S., Mehrnoush A., Karim A.A., Noda T. Mixed biopolymer systems based on starch. *Molecules*. 2012; 17(1):584–597.
5. Fakhouri F.M., Costa D., Yamashita F., Martelli S.M., Jesus R.C., Alganer K (2013). Comparative study of processing methods for starch/gelatin films. *Carbohydrate Polymers*. 2013; 95(2): 681–689.
6. Lee, Dong Sun (2014). "Progress in active food packaging materials." Progress in Nanomaterials for Food Packaging (2014): https://www.futuremedicine.com/doi/book/10.4155/9781909453258.
7. Silvestre, Clara, and Sossio Cimmino (2013). Ecosustainable Polymer Nanomaterials for Food Packaging: Innovative Solutions, Characterization Needs, Safety and Environmental Issues. CRC Press, 2013. https://www.crcpress.com/Ecosustainable-Polymer-Nanomaterials-for-Food-Packaging-Innovative-Solutions/Silvestre-Cimmino/p/book/9781138034266
8. Diaz L. Reales J, Torres C (2017). Measurement of the transmittance of edible films of aloe vera (barbadensis miller) and cassava starch using optical fibers trifurcated. *Journal of Physics: Conference Series*. 2017; 792(1): 012-023.

9. Gutiérrez T, González G (2016). Effects of exposure to pulsed light on surface and structural properties of edible films made from cassava and taro starch. *Food and Bioprocess Technology.* 2016; 9(11): 1812-1824.
10. González SP, Medina JC, Famá L, Goyanes S (2016). Data of thermal degradation and dynamic mechanical properties of starch-glycerol based films with citric acid as crosslinking agent. *Data Brief*. 2016; 7(1): 1331-1334.
11. Ghanbarzadeh, B. Pezeshki Najafabadi, A., Almasi, H (2011). Antimicrobial edible films for food packaging. *JFST*. 2011; 8 (1): 1-22.
12. Basiak, E., Lenart, A., & Debeaufort, F. (2018). How Glycerol and Water Contents Affect the Structural and Functional Properties of Starch-Based Edible Films. Polymers, 10(4), 412. doi:10.3390/polym10040412
13. Senturk Parreidt, T., Müller, K., & Schmid, M. (2018). Alginate-Based Edible Films and Coatings for Food Packaging Applications. Foods (Basel, Switzerland), 7(10), 170. doi:10.3390/foods7100170
14. E. Molaee Aghaee, A. Kamkar, A. Akhondzadeh Basti, A. Khanjari, M.G. Kontominas (2015). Effect of packaging with Chitosan biodegradable films formulated with Garlic essential oil (Allium sativum L.) on chemical properties of chicken fillet. Iran. *J. Health & Environ*. 2015; 8 (3): 1-18
15. Ghasemlou M, Khaksar R, Mardani T, Shahnia M, Rashedi H (2013). Preparation and Investigation of Antimicrobial Biodegradable Edible Film Based on Corn Starch. *Iranian Journal of Nutrition Sciences & Food Technology.* 2013; 7 (5): 115-123.
16. Soukoulis, C., Singh, P., Macnaughtan, W., Parmenter, C., & Fisk, I. D (2016). Compositional and physicochemical factors governing the viability of Lactobacillus rhamnosus GG embedded in starch-protein based edible films. *Food hydrocolloids.* 2016; *52*(1): 876-887.
17. Monserrat Escamilla-García , Andrea Reyes-Basurto , Blanca E. García-Almendárez , Elvia Hernández-Hernández, Georgina Calderón-Domínguez, Giovanna Rossi-Márquez and Carlos Regalado-González (2017). Modified Starch-Chitosan Edible Films: Physicochemical and Mechanical Characterization. *Coatings.* 2017; 7(12): 201-224.
18. Ata Aditya Wardana and Tri Dewanti Widyaningsih (2017). Development of edible films from tapioca starch and agar, enriched with red cabbage (Brassica oleracea) as a sausage deterioration bio-indicator. *IOP Conference Series: Earth and Environmental Science*. 2017; 109 (14): 1-10.
19. Renata Paula Herrera Brandelero, Evandro Martin Brandelero, Fábio Mendonça de Almeida (2016). Biodegradable films of starch/PVOH/alginate in packaging systems for minimally processed lettuce (Lactuca sativa L.). *Ciênc. agrotec*. 2016; 40 (5): 112-125
20. Javanmard, M (2010). Biodegradable Whey Protein Edible Films as a New Biomaterials for Food and Drug Packaging. I*ranian Journal of Pharmaceutical Sciences*. 2010; 5(3): 129-134.
21. Millene Aparecida Gomes; Diego Palmiro Ramirez Ascheri; André José de Campos (2016). Characterization of edible films of Swartzia burchelli phosphate starches and development of coatings for post-harvest application to cherry tomatoes. *Semina: Ciências Agrárias, Londrina.* 2016; 37 (4): 1897-1910.
22. Tabari, M. (2018). Characterization of a new biodegradable edible film based on Sago Starch loaded with Carboxymethyl Cellulose nanoparticles. *Nanomedicine Research Journal.* 2018; 3(1): 25-30. doi: 10.22034/nmrj.2018.01.004
23. Adjouman YD, Nindjin C, Tetchi FA, Dalcq AC, Amani NG (2017). Water Vapor Permeability of Edible Films Based on Improved Cassava (*Manihot esculenta Crantz*) Native Starches. J Food Process Technol. 2017; doi: 10.4172/2157-7110.1000665
24. Andrzej Rejak, Agnieszka Wójtowicz, Tomasz Oniszczuk, Dominika Niemczuk, Małgorzata Nowacka (2014). Evaluation of Water Vapor Permeability of Biodegradable Starch-Based Films. TEKA. *Commission of motorization and energetics in agricultur*e. 2014; 14(3): 89–94.
25. Xiaoyong SDNG, Luming CHENG, Lian TAN

(2018). Edible iron yam and maize starch convenient food flavoring packaging films with lemon essential oil as plasticization. *Food Sci. Technol,* Campinas, Epub December 13, 2018. https://dx.doi.org/10.1590/fst.13118

26. Doles P E, Sumi Maria Babu, Neena Ittera, Indulekha John, Lin John, Neethu John (2014). Tapioca Starch Based Antimicrobial Food Packaging Material. *International Journal of Engineering Research & Technology* (IJERT). 2014; 3 (9): 314-328.
27. Mohammadi Nafchi, A., Olfat, A., Bagheri, M., Nouri, L., Karim, A. A., & Ariffin, F (2017). Preparation and characterization of a novel edible film based on Alyssum homolocarpum seed gum. *Journal of food science and technology*. 2017; 54(6): 1703-1710.
28. Colussi R, Pinto VZ, El Halal SL, Biduski B, Prietto L (2017). Acetylated rice starches films with different levels of amylose: Mechanical, water vapor barrier, thermal, and biodegradability properties. *Food Chemistry*. 2017; 221 (6): 1614-1620.
29. Miculescu F., Maidaniuc A., Voicu S I., Thakur V K., Stan G E., Ciocan LT (2017). Progress in Hydroxyapatite-Starch Based Sustainable Biomaterials for Biomedical Bone Substitution Applications. *Sustainable Chemistry and Engineering.* 2017; 5 (12): 8491-8512.
30. Khan B., Khan Niazi M B., Samin GH., Jahan Z. (2016). Thermoplastic Starch: A possible Biodegradable Food Packaging Material –A Review. *Journal of Food Process Engineering*. 2016; 29 (9) 1745–4530.
31. Ghosh A, Gupta T, Swaminathan J, Wright D (2015). Mechanical and anti-pathogenic characterization of starch-based materials. *Polymer Testing*. 2015; 43 (4): 78-82.
32. Hashemi SMB, ZahabiN, Rezaee Z, Maherani Z, Boghori P (2016). Evaluation of a Starch-Based Edible Film as Carrier of Adiantum Capillus-Veneris Extract to Improve the Shelf Life of Fresh-Cut Pears. *Journal of Food Safety.* 2016; 36(3): 291-298.
33. Muscat, D., Adhikari, B., Adhikari, R. and Chaudhary, D. S (2012). Comparative study of film forming behaviour of low and high amylose starches using glycerol and xylitol as plasticizers. *Journal of Food Engineering.* 2012; 109 (1): 189-201.
34. Li, M., Liu, P., Zou, W., Yu, L., Xie, F., Pu, H., Liu, H. and Chen, L (2011). Extrusion processing and characterization of edible starch films with different amylose contents. *Journal of Food Engineering,* 2011; 106 (2): 95-101.
35. Jung J., Gopinath k., Seo J (2018). Development of Functional Antimicrobial Papers Using Chitosan/starch-silver Nanoparticles. *Biological Macromolecules,* 2018; 112(5): 530- 536.
36. Jung J., Raghavendra GM., KimD., Seo J (2018). One-step Synthesis of Starch-silver Nanoparticle Solution and Its Application to Antibacterial Paper Coating. *Biological Macromolecules*, 2018; 107 (6): 2285-2290.