Chapter

Natural Polymers as Potential Antiaging Constituents

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Abstract

Active pharmaceutical ingredients and pharmaceutical excipients are the core of any pharmaceutical preparation. API's are responsible for the therapeutic activity while excipients are non-pharmacological ingredients which are used in the manufacturing of pharmaceutical preparations. As we know that some polymers have thickening property, also the water based formulations are fluid in nature therefore in order to change the rheology of such formulations various polymers are used. These polymers act by increasing the viscosity of formulations. Starch, guar gum, alginates, pectin, gelatin, agar, carrageenan, cellular derivatives are the examples of natural polymer that are used to increase the viscosity of water based formulations meant for topical application. The present review deals with the use of such natural polymers as constituents of anti-aging formulations. As is well-known that aging is a natural process in which rate of production of new cells reduces while the rate of degradation of old cells increases because the normal physiology of body changes and free radicals produced by mitochondria as a byproduct and are oxygen containing highly reactive molecules. The antiaging preparations basically neutralize the effect of free radicals and protect our cell from premature degradation. On a contrary note, the already in use synthetic polymers have adverse effect on human body as well as on environment. It is well advocated in various researches that natural polymers have no or less side effects in comparison to synthetic polymers, giving them a positive lead for incorporation to various antiaging formulations. The present review gives a deep insight on the nature of polymers used over ages, there applications and incorporation into different cosmeceuticals. It also discusses the process and mechanism of aging and the phenomenon by which cell damage can be overcome. Finally, the authors have concluded with the upcoming scenario of the use of naturally derived polymers in various skin care preparations.

Keywords: polymers, antioxidant, aging, free radicals, antiaging agents

1. Introduction

Polymers are non-pharmacological agents and use as excipients. They possess special properties and are used in site targeting, taste masking and to increase patient compliance [1].

Herman Staudinger, Nobel Prize winner (1953) German scientist coined the term "Macromolecules" in reference to Polymer [2].

The word 'Polymer' is derived from the Greek word and is made up of two words 'Poly' and 'meros'. Poly means 'many' and meros (Mers) mean 'parts or units of

high molecular mass'. Polymer molecule consists of a large number of repeated units of monomers by covalent bonds. The monomer is a single structural unit while the polymer is macromolecule.

- Monomer = single structural unit.
- Dimer = two repeated units of monomer.
- Polymer = more than two repeated units of monomers [3].

Polymerization is a chemical process through which two or more than two monomers are attached together and formed a macromolecule (polymers) in which there is repeated units of monomers.

2. Ideal properties of polymers

1. It should be inert and compatible with environment.
2. It should be non-toxic.
3. It should be easily administered.
4. It should be easy and inexpensive to fabricate.
5. It should have good mechanical strength.
6. It must be compatible with body fluids.
7. It should have no pharmacological action [7].

3. Types of polymer

3.1 On the basis of source

1. Natural polymer
2. Semisynthetic polymer
3. Synthetic polymer

Natural polymers: Natural polymers or herbal polymers obtained from nature mean they are obtained from plants and animals. If they are obtained from plant then they are known as "herbal polymers" (**Table 1**).

Example: starch, protein, cellulose.

Semisynthetic polymer: These polymers are prepared by chemical process in which natural polymers are used as raw material.

Example: silicones, cellulose derivatives.

Synthetic polymers: These are pure synthetic material and are prepared by chemical process called polymerization.

Example: polyethylene, synthetic rubbers, nylon, etc.

Sr. no.	Natural polymer	Source	Properties	Reference
1	Starch	Potatoes, maize, rice, wheat, etc.	Act as disintegrant Act as binder	[15–17]
2	Guar gum	Guar beans	Thickening properties Stabilizing properties	[15, 18–22]
3	Alginates	Present in cell wall of brown algae	Thickening properties	[23–27]
4	Pectin	Present in cell wall of terrestrial plants	Thickening properties Stabilizing properties	[28–32]
5	Gelatin	Obtained from animal body parts like bone and skin	Used as a carrier, coating or separating agent	[33–37]
6	Agar	Present in cell wall of Algae *Agarophyte*	Thickener, laxative, appetite suppressant	[15, 38]
7	Carrageenan	Extracted from red edible sea weeds	Thickening properties Stabilizing properties Binding property	[19, 39–41]
8	Tragacanth	Dried gum obtained sap of several species of genus *Astragalus*	Thickening properties Stabilizing properties Binding property	[42]
9	Cellulose	Present in cell wall of green plants, algae and Oomycetes	Thickening properties Stabilizing properties	[8–12, 43–45]
10	Psyllium	Seeds of Plantago	Thickening properties Production of mucilage	[46, 47]

Table 1.
Natural polymers along with their source and properties.

3.2 On the basis of structure

1. Linear polymers

2. Branched polymers

3. Cross linked polymers

Linear polymers: In this, monomers are arranged in a straight-line chain.
Example: PVC.

Branched polymers: In this, there is also a long straight chain, but small monomer chains are attached to this large straight chain.
Example: low density polymers.

Cross-linked polymers: These types of polymers look like a network in which polymeric chains are cross linked with each other [2–6].

4. Advantages of natural polymer over synthetic polymer

1. All synthetic polymers are produced by chemical process so they causes adverse effect on environment as well as human being while natural polymers are produced from natural origin i.e. plants and animals and do not have any adverse effect.

2. The production cost of natural polymer is less than synthetic polymers.

3. Natural polymers are non-toxic and safe for human use as well as for environment while synthetic polymers are pure chemicals they are not as safe as natural polymer.

4. Natural polymers are produced by many countries because of their demand in industries due to their less/no side effect and they are produced in the form of herbs so production is economic [13].

5. Drawbacks of natural polymers

1. The chemical constituent present in natural polymer is affected by various factors like climate or geographical conditions, availability of nutrition, so difference in the chemical constituent in each batch is possible.

2. During production they are directly exposed to environment so risk of microbial contamination is very high.

3. In order to protect herbs from pests various pesticides like DDT are used which is harmful for human being.

4. Herbal polymers are produced by different herb so rate of growth of herb is affected by the environment, altitude, humidity, availability of nutrition, etc.

5. Herbal polymers may adulterated by similar looking herbs so validation is required.

6. The chemical constituent present in herb may be extracted out previously so validation/standardization of herbs is required [13, 14].

6. Applications of polymers in pharmacy

1. Polymers are used to mask the taste and odor of bitter taste of the drug.

2. Enteric coated polymers are useful in the site specific drug delivery.

3. In controlled release drug delivery system, the reservoir containing drug separated from the biological fluids by a water insoluble polymeric film.

4. Sometimes drugs are coated with hydro-swellable polymers for prolonged released.

5. To protect the drug from the acidic environment of the stomach, the water insoluble polymer material is used. Example: ethyl cellulose.

6. Biodegradable polymers are used to make matrix systems in which drug is incorporated in controlled release drug delivery system.

7. Polymers also used as binder (example: ethyl cellulose, HPMC, etc.) and disintegrant (example: PVP, starch, sodium CMC) in tablet manufacturing.

8. Polymers are used as diluents to increase the mass for tablet compression.

9. In order to modifying drug release polymers may be coated with polymeric film. The thickness of film is 10–100 mm.

10. Various hydrophilic polymers are used for enhancing physical stability of pharmaceutical disperse system. Example: alginate, PVP, etc.

11. Drug polymer conjugates are used to alter the pharmacokinetic of drug and ultimately improving bioavailability. This strategy is also used in the treatment of cancer [8–12].

7. Aging process

Aging is a natural process in various changes occurs in normal physiological process and ultimately increases the risk of disease and death of cell, tissue and organ (**Table 1**).

One of the major causes of aging process is the cellular damage that causes the shortening of DNA, leading to the process called apoptosis. Apoptosis is a process in which cell is programmed to be death in given life spam. This process is important when we realized that each cell contain genetic material and mitochondria or power house of cell. As we know that mitochondria serves as an energy generator during normal cell process and free radicals are produced a byproduct and these free radicals damage DNA and creating DNA fragments and triggers cell to apoptosis.

As time passes the more free radicals damages more DNA and fragments increase the process of cell apoptosis and our body cannot generate cells faster enough to maintain or compensate loss, so in older age we have very thin skin in comparison to young age.

In another process, the cellular down-regulation of enzymes such as superoxide dismutase, catalase and glutathione peroxide which are natural oxidative enzymes which making our antioxidant defense lesser efficient with age.

As we grow with age, the process of cellular reproduction increases and body creates non-functional cells along with functional cells, leading to rapid deterioration of the body's function. As we grow with age, the more numbers of useless cells are formed which interfere with normal cellular processes and leading to the aging process.

Free radicals: Free radicals produced by mitochondria as a byproduct and are oxygen containing highly reactive molecules with single electron in the outermost orbital that are very eager to pair up with anything else that has electrons. The life span of free radical is one-millionth of a second. Free radicals attack on cell's DNA and destroy cell prematurely and during young age out antioxidant defense system protect the cell from free radicals but as we grow this system weekend and not be able to work efficiently [48, 49].

7.1 Theories of aging

1. Genetic theory

2. Non-genetic theory

3. Error theory

4. Wear and tear theory

5. Cross linking theory

6. Autoimmune theory

7. Oxidative damage theory

7.1.1 Genetic theory

This theory demonstrates that gene of an animal or human being contains a 'program' of life span. The genetic theory of aging focuses on telomeres which are repeated units deoxyribonucleic acid and are present at the end of chromosome. The number of repeats in a telomere defines the life span of a cell, and multiple repeats are lost when each time a cell divides. When telomere has been reduced to a certain size, the cell reaches at a stage where it is prevented from further dividing, at this stage cell die.

7.1.2 Non-genetic cellular theory

According to this theory accumulation of harmful substance in the cells lead to aging process. Lipofuscin a dark colored insoluble substance that is accumulates day to day. This cellular garbage or cellular waste interferes with the physiology of cells and ultimately lead to death of the cell.

7.1.3 Error theory

Sometime during RNA transmission process a mutant protein or enzyme is produced which is not the exact same copy of original then it is not be able to work well in maintaining life, as a result cell grows and die. As we know that RNA are unstable molecules and formed continuously while DNA are stable molecules and maintained throughout the lifespan of cell and tissue.

7.1.4 Wear and tear theory

Changes in the internal and external environment of the cell cause cell damage and cell will not work their function efficiently. As time passes, changes in the more numbers of the cell functioning lead to change the normal physiology of body and lead to aging and death.

7.1.5 Cross linkage theory

As time passes deoxyribonucleic acid, different molecules and structural molecules develop a cross-linking with each other. These unwanted links/bonding decrease the mobility and elasticity of proteins and other molecules as a result molecule will not work efficiently. This cellular damage stick surround and can cause problems and cross linking appears when weakened immune system is unable to clean up the unwanted glucose in the blood. These sugar molecules react with adjacent neighbor and can cause cross-linking and lead to formation of free radicals.

7.1.6 Immunological theory

Immune system protect our body from different pathogens, disease, etc. they act by producing antibody against antigen and they also act engulfing and digest foreign cell by phagocytosis.

As time passes and we get older out body losses the ability to differentiate between own cells and foreign material and then immune system sometime destroying own cells along with foreign particles.

7.1.7 Oxidative damage theory

Denham Harman proposed free radical theory of aging in 1950s and according to this theory oxygen free radicals formed during normal metabolic process just because of lot of oxidative damage to macromolecules. This theory is further modified and a new theory came in existence that is 'Oxidative Stress Theory of Aging'. According to this theory oxygen species like peroxide and aldehyde are not technically free radicals but they play an important role in oxidative damage to cell. As age passes the imbalance between proxidant and antioxidant leads to an accumulation of oxidative damage in variety of macromolecules and cause failure of normal cellular process and leading to aging [49, 50].

8. Topical anti-aging agent

Antioxidant and cell regulators are the main agents which are used for antiaging action. Antioxidants such as ascorbic acid, polyphenols and flavonoids reduces the collagen degradation by reducing the concentration of free radicals, while cell regulators (retinol, peptide, growth regulators) affect the collagen metabolism and stimulate collagen production.

Ascorbic acid, tocopherol, niacinamide is low molecular weight antioxidant and they have the ability to penetrate skin. L-Ascorbic acid is water soluble photosensitive substance having anti-aging action at the concentration of 5–15% and act by inducing the production of collagen 1 and collagen 3. Several enzymes are also important in the production of collagen.

The combination of vitamin E and vitamin C is more effective in comparison to individual effect of vitamin E and vitamin C.

8.1 Niacinamide (B_3)

Vitamin B_3 regulates the cellular physiology such as metabolism and regeneration and is effective as anti-aging agent at concentration 5%. A result comes from clinical study that elasticity, erythema and pigmentation of study were improved after topical application for 3 months.

8.2 α-Tocopherol (vitamin-E)

Vitamin E is used in the cosmetic cream because of its anti-inflammatory and anti-proliferative activity at the concentration 2–20%. Vitamin E smoothing the skin and act by increasing the cell's ability to maintain humidity and accelerate the process of epithelialization and protect the skin from sunlight but it is not as such effective as combination of vitamin C and vitamin B_3.

Some botanicals such as isoflavones from soya and topical application of green tea polyphenols decreases the number of langerhans cells and reduces deoxyribonucleic acid damage in skin.

Cell regulators such as retinol derivatives (retinaldehyde and tretinoin), polypeptides and botanicals act by affective collagen metabolism and increase the production of collagen and elastic fibers.

Retinol and its derivative such as retinaldehyde and tretinoin are antioxidant and have anti-aging action. They stimulate the synthesis of collagen and reduce the expression of matrixmetaloproteinase-1. Retinol is most commonly used topical cosmetic preparation in comparison to tretinoin because it causes less irritation.

Tretinoin is the nonaromatic retinoid of the first generation and is approved by United States for topical application as an anti-aging treatment at the concentration of 0.05%. It is used for the treatment of wrinkles, ultra violet induced skin aging, pigmentation and loss of skin elasticity.

Polypeptides also have a capacity to stimulate collagen synthesis and activate dermal metabolism [51–53].

9. Types of antioxidant

Three types of anti-oxidant found in nature i.e. phytochemicals, vitamins and enzymes. Potent anti-oxidants are found in plants because plants are exposed to ultra violet light throughout of the day. Plants generate high quantity of free radicals but they do not cause cellular damage, because they are protected by naturally occurring anti-oxidant defense system.

9.1 Anti-oxidant enzymes

These enzymes are basically antioxidant and are synthesized in human body when eat proteins and minerals as our daily diet. The examples of these enzymes are superoxide dismutase, glutathione peroxide, glutathione reductase and catalases. They require co-factors such as iron, copper, selenium, magnesium and zinc for anti-oxidant activity.

9.2 Anti-oxidant vitamins

Human body is not able to synthesize or produce these anti-oxidant vitamins naturally but they require for maintaining normal physiology and health, so we take these vitamin in our daily diet. Retinol, L-ascorbic acid, α-tocopherol, folic acid and beta-carotene are the examples of anti-oxidant vitamins.

Retinol is important in tissue repair, for eye health, for improving immune system as well as for improving cholesterol level. L-Ascorbic acid protects our skin from ultra violet light damage and it stimulates immune system by providing resistance from infection and helps in regulating cholesterol level.

α-Tocopherol play an important role in maintaining health of blood vessels and it also improve the skin condition by protect the cell's membrane. Folic acid is useful in the process of erythropoiesis.

Various phytochemicals such as carotenoid provide protection against singlet oxygen and free radicals. These carotenoids are found in orange-colored vegetables like carrot as well as in dark green vegetables like kale, etc.

9.3 Anti-oxidant phytochemicals

Phytochemicals are natural anti-oxidant and they are found in plants and used by plants in order to protect themselves from free radicals. Phytochemicals are naturally fount in whole foods like whole grains, fruits and vegetables. Phytochemicals may be dividing into following category.

1. Carotenoids

2. Flavonoids

3. Polyphenols

4. Allyl sulfides [54]

10. Natural anti-oxidant in human body

As we know that free radicals attack on DNA and interferes with normal physiology of cell and to protect DNA from these attacks a series of defense mechanism is developed by body. Anti-oxidant act at different levels and by different mechanism in the defense system such as preventive mechanism, radical scavenging and repair and adaptation (**Table 2**).

1. First line of defense

2. Second line of defense

3. Third line of defense

4. Fourth line of defense

10.1 First line of defense

Preventive oxidants are the first line of defense and they act by suppressing the formation of free radicals. Catalase (CAT), glutathione peroxide (GPx) and superoxide dismutase (SOD) are the examples of enzymatic oxidants.

10.2 Second line of defense

In second line of defense include retinol, α-tocopherol, uric acid, bilirubin, albumin and thiols. This anti-oxidant scavenges the active radicals and breaks the chain propagation reaction and suppresses chain initiation.

10.3 Third line of defense

Third line of defense includes proteolytic enzymes, proteinases and peptidases present in the cytosols and in the mitochondria of mammalian cells, etc. they act by repair deoxyribonucleic acid.

10.4 Fourth line of defense

Fourth line of defense include adaptation, in this signals for the production and reaction of free radicals induce the formation of antioxidant and they also transport the suitable antioxidant to the right place.

Various types of natural antioxidant fount in nature and they are differ in their specifications, mechanism of action and their composition, etc. [55–59]

11. Enzymes

These enzymes act as antioxidant and act by converting reactive oxygen species and reactive nitrogen species into stable compound and is important in the repairing of damaged DNA, Proteins and oxidized peroxides.

11.1 Superoxide dismutase (SOD)

Superoxide dismutase catalyzes the breakdown of superoxide anion into hydrogen peroxide and oxygen. These enzymes are present in aerobic cells as well as in extra cellular fluids. In plants, superoxide dismutase are present in chloroplast, peroxisomes and apoplast in cytosol, while in human body superoxide dismutase-1 present in cytoplasm and superoxide dismutase-2 in mitochondria and superoxide dismutase-3 in extracellular [59–64].

11.2 Catalase

Catalase is an enzyme and present in almost all living organism which are exposed to oxygen and its function is to catalyze the decomposition of hydrogen peroxide into water and oxygen. As we know that hydrogen peroxide is harmful substance and produced by various metabolic processes and to prevent damage from hydrogen peroxide, catalase converts the hydrogen peroxide into water and oxygen [65].

11.3 Glutathione

Glutathione is a cysteine containing peptide found naturally in aerobic organism and it is not required in daily diet because it is synthesized in cells from amino acids [66]. Thiol group in its cysteine moiety of glutathione is responsible for antioxidant activity. Glutathione is one of the most important cellular antioxidant enzymes which present in high concentration and play an important role in maintain redox state of cell [67].

11.4 High molecular weight compounds

Metal catalyzed free radicals production is restricted by few high molecular weight compounds like albumin, transferrin, ceruplasmin, etc. [68]

11.5 Low molecular weight compound

Low molecular weight compounds like Tocopherol, quinines, bilirubin are lipid soluble antioxidant while ascorbic acid, uric acid are water soluble antioxidants [69].

11.6 Minerals

Selenium, copper, manganese, zinc are mineral antioxidants. Copper shows antioxidant activity through SOD while zinc is necessary for normal growth and reproduction of body [70].

11.7 Vitamins

Vitamins re organic molecules and essential for normal growth of body and helpful in maintain normal physiology of body. Retinol, ascorbic acid and tocopherol are popular antioxidant agent [71, 72].

11.8 Ascorbic acid

L-Ascorbic acid or vitamin-C is a monosaccharide antioxidant found in animals as well as in plants e.g., citrus fruits. Human body is not able to synthesize vitamin-C, so it is taken in food as regular diet. Inside the cell, it is maintained in its reduced form by reacting with glutathione, which further catalyzed by protein disulfide, glutaredoxins and isomerase [73].

Actually vitamin-C is a reducing agent and can reduce, thereby neutralize reactive oxygen species, such as hydrogen peroxide [74].

11.9 Tocopherol and tocotrienols

Vitamin E is fat soluble vitamin with antioxidant properties, and a collective set of eight related tocopherol and tocotrienols [75]. α-Tocopherol is one of the most important lipid soluble antioxidant and it protect the cell membrane from oxidant by reacting with lipid radicals which are formed in lipid peroxide chain reaction [76]. These free radical intermediates are then removed and prevents the propagation reaction from continuing. In this reaction oxidized α-tocopherol radicals are formed which recycled back to the active reduced form through reduction reaction by other antioxidants such as vitamin-A, etc. [77]

11.10 Melatonin

Melatonin is produced by the pineal gland and have bleaching action on skin pigment i.e. melanin. Melatonin is used as a protective agent against various processes and agents which damage the tissue via free radicals. Melatonin is found in all living organism. As we know that melatonin is a naturally occurring hormone and chemically is N-acetyl-5-methoxytryptamine [78] and found in animals and in algae [79].

Melatonin is highly lipophilic in nature and having an ability to cross various barriers like cell membrane as well as highly selective barriers like BBB [80]. Melatonin also known as 'suicidal anti-oxidant' because it cannot be recycled when it reduced to its former state [81].

11.11 External anti-oxidant

As we know that our body is programmed to generate own antioxidants to protect life but body is also designed to fight inflammation, disease and toxins naturally. In order to support these internal antioxidant systems we also take some

external antioxidant in our diet as regular meal. External antioxidant include vitamins and some specific food products, etc.

Peoples who eats fresh fruits and vegetables regularly have lower risk of health loss. Some heart disease is also prevented by taking tocopherol as nutritional supplement [82].

Nutritional supplement include specific antioxidant chemicals like polyphenol, resveratrol and some other minerals and vitamins. Spices like turmeric, coriander, cumin, fennel also have medicinal properties. Food and part of foods which provide medicinal benefit known as "Nutraceuticals". These nutraceuticals also helpful in maintaining normal physiology of body [83] (**Table 2**).

Sr. no.	Antiaging agent	Source	Mechanism of action	Reference
1	Retinol	Eggs, dairy products, cod liver oil, cheese, liver, butter, etc.	Act by inducing the production of collagen-1 and collagen-2	[71]
2	Tocopherols	Olive oil, almond oil, sunflower oil, peanut oil, oats, goat's milk, almonds, poppy seed oil, carrots and asparagus, etc.	It act by smooth the skin and increase the ability of stratum corneum to hold humidity and increase the process of epithelial cell formation	[76]
3	Ascorbic acid	Orange, lemon, strawberry, apple, carrot, pear, grape fruits, pine apple, banana and avocado, etc.	It act by neutralizing reactive oxygen species such as hydrogen peroxide	[74]
4	Hydroxy acid	Pine apple, lemons, grape fruits, papaya, tomato and plain yogurt, etc.	It act by removing old dead skin and promote formation of new skin	[84]
5	Co-enzyme (ubiquinone)	Red meat, soybean oils, rapaseed oils, sesame oils, oily fish like tuna and salmon, etc.	Act by neutralizing free radicals and increase the production of collagen	[85]
6	Tea extract	Leaves of green and black tea e.g. *Camellia sinensis*	Polyphenols present in tea act by reduce the formation of free radicals	[86]
7	Grape seed extract	Seeds of grapes	Grape seeds contain phytochemicals like gallic acid, catechin, and epicatechin and these phytochemicals are useful in the production of antioxidative supplements	[87]
8	Niacinamide	Sword fish, tuna fish, white meat, corn, green vegetables, grains, yeast, etc.	Maintain moisture content in skin as well as regulate cell regeneration	[88]
9	N-acetyl glucosamine	Shells of crabs, shitake mushroom, shark cartilage, dumontiaceae (red Japanese algae)	Act by improving skin moisturization	[89]
10	Peptides	Milk, eggs, grain, soybean etc.	It act by increasing collagen production and inhibit the breakdown of collagen	[90]

Table 2.
Antiaging agents, natural source along with their mechanism of action.

12. Role of polymers in anti-aging preparations

1. As thickeners

2. As structuring agent

3. In hair products

4. As delivery system

12.1 As thickeners

As we know that some polymers have thickening property and water based formulations are fluid in nature and in order to change the rheology of these formulations these polymers are used. These polymers are used to increase the viscosity of these formulations.

12.1.1 Natural thickeners

Starch, guar gum, alginates, pectin, gelatin, agar, carrageenan, cellular derivatives are the examples of natural polymer that are used to increase the viscosity of water based formulations.

12.1.2 Synthetic thickeners

Polyacrylate derivatives, polyacrylamide are most commonly used synthetic polymers in cosmetic industry.

12.1.3 Role of natural polymers as thickening agent in antiaging preparations

Thickening agent or thickener is a substance which are used to increase the viscosity of fluid.

12.1.4 Xanthan gum

Xanthan is a polymer and consist of a repeating units of pentasaccharides (two D-glucopyranosyl unit, two D-mannopyranosyl unit and one D-glucopyranosyluronic unit). It is a free flowing powder and gives a viscous solution in hot as well as in cold water even at low concentration. It is widely used in cosmetic, toothpaste as well as in antiaging preparations.

12.1.5 Pectin

Pectin is obtained from various citrus peels like orange peel and other peels of various family but citrus peels have highest concentration i.e. 20–30%. In pharmaceutical industry pectin is used as binding agent in tablets as well as used to increasing the viscosity of fluids.

12.1.6 Carrageenan

It is obtained from the various species of red seaweed of class Rhodophyceae like *Chondrus crispus*, *Eucheuma cottonii*.

Carrageenan is used in the manufacturing of shells of soft and hard gel capsules as substitution of gelatin. Carrageenan is also used to increase the viscosity of formulations which are liquid in nature.

12.1.7 Guar gum

The botanical source of guar gum is *Cyamopsis tetragonoloba*. The composition of guar gum is sugar galactose and mannose. It is used as stabilizer, thickening agent in liquid formulation and as a binder and disintegrant in solid dosage form i.e. tablet [1].

12.2 Structuring agent

In order to add rigidity natural and synthetic waxes, lanolin, long-chain fatty alcohols and triglycerides are used. Poly α olefin is used in the preparation of lip products. Glycol stearates is used as opacifier, which gives a pearlizing affect.

12.3 In hair products

Cationic polymers are used in hair products since hair is negatively charged.

12.3.1 Natural polymers in hair product

Polysaccharides (starch and cellular derivatives), natural gums and hydrolyzed proteins are used as natural polymer in hair product.

12.3.2 Synthetic polymers in hair product

Silicones, polyurethanes, poly vinyl amides, poly vinyl pyrrolidone and acetate polyurethanes are the examples of synthetic polymers.

12.4 Delivery system

Sometime polymers are used as a carrier to deliver active pharmaceutical agent i.e. antioxidant. Natural antioxidant include ascorbic acid, tocopherols, grape seed extract along with synthetic extract like butylated hydroxyl anisole/butyl hydroxyl toluene. E.g. polyanhydride ester is used as a carrier to deliver salicylic acid (anti-acne agent) [91, 92] (**Table 3**).

13. Conclusion

The attitude and lifestyle of society changes from last decades and they are more conscious for their health and appearance due to this change various new antiaging formulations are introduced in market. Antiaging formulations generally contain antioxidants and vitamins like vitamin-E (tocopherol), ascorbic acid, etc. The cosmetic industry is one the growing industries in the India, not even in India but throughout the world. Various new formulations like creams, face washes, face pack, emulsions are introduced day by day. As we know that synthetic chemicals show various side effects on human body, due to this peoples prefer polyherbal

Sr. no.	Work done	Formulation	Polymer used	Author	Year	Reference
1	Formulation and evaluation of natural antioxidants creams comprising methanolic peel extract of *Dimocarpus longan*	Cream	Stearic acid	Alifah Ilyana et al.	2016	[93]
2	Formulation and characterization of herbal face wash/scrubber	Face wash	Carbopol 940	D.K. Sanghi et al.	2016	[94]
3	Formulation and evaluation of herbal vanishing cream	Cream	Stearic acid	Dr. Satyanarayan et al.	2016	[95]
4	Formulation and evaluation of polyherbal face wash gel	Face wash	Carbopol	X. Fatima grace et al	2015	[96]
5	Preparation and evaluation of turmeric herbal formulation	Cream	Stearic acid	Ramya Kuber et al.	2015	[97]
6	Formulation and in-vitro evaluation of the topical antiaging preparation of the fruit *Benincasa hispida*	Cream	Methyl Cellulose	Vidya Sabale et al.	2015	[98]
7	Antiaging activities of polysaccharides from *Athyrium multidentatum* (Doll.) Ching	Paste	Protein	Dongmei Liu et al.	2015	[99]
8	A novel *Cassia fistula* (L.)-based emulsion elicits skin anti-aging benefits in human	Cream	Stearic acid	Barkat Ali Khan et al.	2015	[100]
9	Development and evaluation of antimicrobial herbal cosmetic preparation	Cream	Stearic acid	Sonika Pandey et al.	2014	[101]
10	Formulation and evaluation of polyherbal cosmetic cream	Cream	Stearic acid	X. Fatima grace et al	2014	[102]
11	Promotion and computation of inhibitory effect on tyrosinase activity of herbal cream by incorporating indigenous medicinal plant	Cream	Stearic acid	Amit Roy et al.	2014	[103]

Sr. no.	Work done	Formulation	Polymer used	Author	Year	Reference
12	Formulation and evaluation of herbal antioxidant face cream of nordostachys collected from Indian Himalayas region	Face cream	Stearic acid	Priyanka Tiwari et al.	2014	[104]
13	Formulation and development and compositions comprising arbutin, tretinoin and triamcinolone	Cream	Stearic acid	V. Muruganantham et al.	2014	[105]
14	Formulation and evaluation of antiaging poly herbal cream	Cream	Methyl cellulose, microcrystalline cellulose, sodium alginate	Santhosh Aruna et al.	2014	[106]
15	Formulation and evaluation of antiwrinkle activity of cream and nano emulsion of *Moringa oleifera* seed oil	Cream and nanoemulsion	Stearic acid	Asma Shaheda et al.	2014	[107]
16	Development of antiaging cream from chicken feather	Cream	Keratin	Kausar et al.	2014	[108]
17	Preparation of antiaging collagen face mask	Face mask	Soluble starch, sodium carboxy methyl cellulose	Zibin Shu et al.	2014	[107]
18	Preparation and evaluation of polyherbal cosmetic cream	Cream	Stearic acid	Ashish Aswal et al.	2013	[109]
19	Formulation and development of whitening polyherbal cream	Cream	Stearic acid	Sahu R.K. et al.	2012	[110]
20	Formulation and development of face cream containing natural products.	Cream	Stearic acid	Sahu R.K. et al.	2012	[111]
21	Formulation and evaluation of herbal cream containing *Curcuma longa*	Cream	Stearic acid	Sujith S. Nair et al.	2012	[112]
22	Formulation and evaluation of curcuminoid based herbal face cream	Cream	Saric acid	Sahu Alakh N. et al.	2011	[113]
23	Formulation and evaluation of *Cyperus rotundus* and *Cucumis sativus* based herbal face cream	Cream	Stearic acid	Shailini Sharma et al.	2011	[114]

Sr. no.	Work done	Formulation	Polymer used	Author	Year	Reference
24	Formulation and evaluation of herbal cosmetic preparation using safed musli	Cream	Stearic acid	V.V. Painthankar et al.	2010	[115]
25	Formulation and evaluation of cream of *Azadirachta indica* leaves extract on skin renewal rate	Cream	Stearic acid	Kamlesh J. et al.	2009	[131]

Table 3.
Natural antiaging agent reported till date.

formulations which contain antioxidant along with natural polymers. Polymer in antiaging formulations serve as a thickening agent like guar gum, pectin etc. and as a structuring agents.

Polymers non-pharmacological agents and used as an ingredient in various formulations. Natural and synthetic both polymers are used in pharmaceutical industry but because of the side effects of synthetic polymers, the attitude of the people changed and they prefer natural polymers containing antiaging formulations. The demand of natural polymer containing antiaging agents increases day by day, this change causes change in manufacturer to use herbal polymers instead of synthetic polymers.

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