

Polysaccharides: Concepts and Classification

Lismet Lazo Delgado and Martin Masuelli*

Physical Chemistry Research and Services Laboratory (LISEQF-UNSL), INFAP-CONICET-National University of San Luis, Argentina

***Corresponding author:** Dr. Martin A Masuelli, Laboratorio de Investigación y Servicios de Química Física (LISEQF-UNSL), Instituto de Física Aplicada-CONICET-Universidad Nacional de San Luis, Ejercito de los Andes 950, ZC: 5700, San Luis, Argentina, Tel: +54-0266-4520300 (int. 1655); Email: masuelli@unsl.edu.ar

Received Date: April 18, 2019; **Published Date:** April 25, 2019

Introduction

The polysaccharides are macromolecules that belong to different living beings, whose components are monosaccharides joined in a biopolymeric chain. Together with nucleic acids and proteins, polysaccharides determine the functionality and specificity of the species. Polysaccharides have received little promotion despite being widely distributed in nature. They are important molecules that intervene throughout the body in signal transduction and cell adhesion [1]. They are also called carbohydrates. We can define polysaccharides as biomolecules formed by the union of a large amount of monosaccharides. They are among the carbohydrates, and perform diverse functions, especially of structural and energy reserves [1-2].

The polysaccharides are polymers whose constituents (their monomers) are the monosaccharides, which are joined repetitively by glycosidic bonds. These compounds have a very high molecular weight, which depends on the number of residues or units of monosaccharides that participate in their structure. This number is almost always indeterminate, variable within some margins, unlike what happens with biopolymers that carry information, such as DNA, RNA or proteins, which have a fixed number of pieces in their chain, in addition to a specific sequence [1].

The polysaccharides can be broken down, by hydrolysis of the glycosidic bonds between residues, into smaller polysaccharides, as well as into disaccharides or

monosaccharides. Hydrolysis can be thermal, acidic, basic, enzymatic and using microorganisms [1].

Polysaccharides can be broadly classified into three groups based on their properties, which are closely related to their appearance in nature: structural, storage, and gel formation. A classic classification considers four divisions could also be added according to the origin or provenance of nature. The first compounds used at the industrial level were polysaccharides. Polysaccharides as polymers are by far the most abundant of the earth's renewable resources with an annual formation rate exceeding the global production rate of synthetic polymers by a few orders of magnitude.

In contrast, synthetic polymers based on petroleum, polysaccharides of vegetable origin are sustainable materials produced by the sun's energy and totally biodegradable in their original state. Therefore, with the decrease in oil supply, polysaccharides are valid resources to replace them. The most abundant polysaccharides are cellulose, starch, chitin, and hemicelluloses. These materials are expected to play an increasingly important role in the materials industry. Polysaccharides are designed by nature to carry out various specific functions. Polysaccharides are highly functional biopolymers with great structural diversity and functional versatility. Its structural and functional properties are often superior to synthetic materials [1-4].

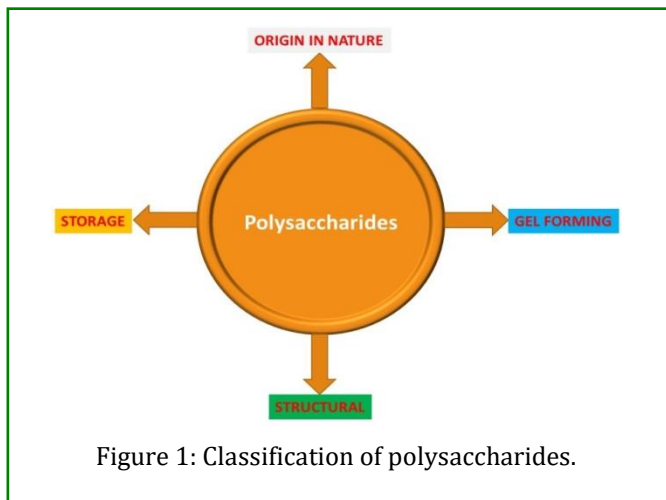
Polysaccharides can be broadly classified into four groups depending on which are closely related to their occurrence in nature [1]:

- a. Storage or Reserve
- b. Structural
- c. Gel Forming
- d. Origin in nature

Other classifications may consider the following:

- a. Ionics
- b. According to your application

This polysaccharides classification can be seen in Figure 1.



There are two types of polysaccharides according to their composition: 1- The homopolysaccharides are formed by the repetition of a monosaccharide. 2- The heteropolysaccharides are formed by the orderly repetition of a disaccharide formed by two different monosaccharides (or, what is the same, by the alternation of two monosaccharides). Some heteropolysaccharides participate together with polypeptides (amino acid chains) of various mixed polymers called peptidoglycans,

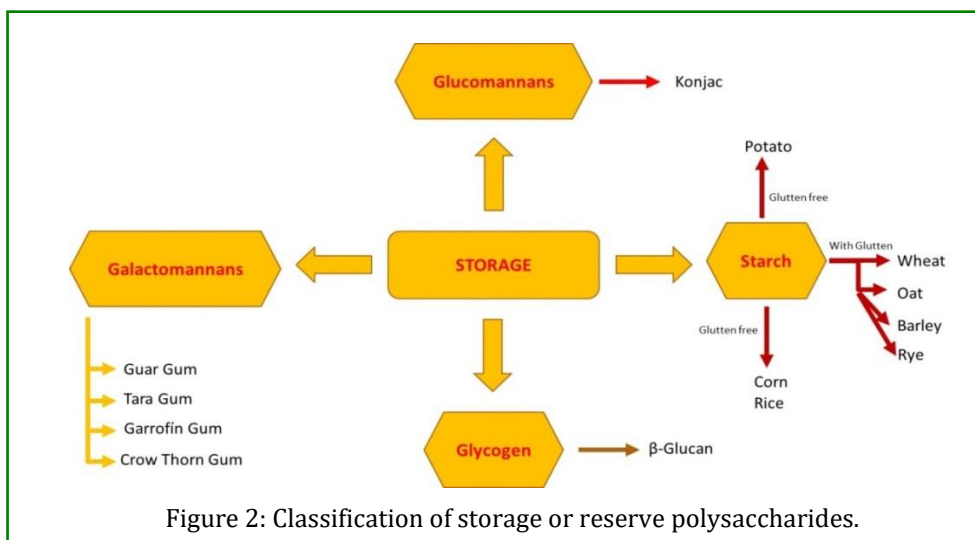
mucopolysaccharides or proteoglycans. It is essentially structural components of tissues, related to cell walls and extracellular matrices [5].

Reserve or Storage Polysaccharides

Reserve polysaccharides represent a way of storing sugars without creating an osmotic problem. The main molecule that supplies energy to the cells of living beings is glucose. Its storage as a free molecule, since it is a small and very soluble molecule, would lead to severe osmotic and viscosity problems, incompatible with cellular life. The organisms then maintain only small and very controlled amounts of free glucose, preferring to store it as a biopolymer. The osmotic concentration depends on the number of molecules, and not on their mass, so the cell can, in this way, store huge quantities without presenting problems. Some examples of reserve polysaccharides can be: starch and glycogen [1].

It is important to note that reserve polysaccharides do not play the same role in immobile and passive organisms, such as plants and fungi, then in animals they store only a small amount of glycogen, which serves to ensure a permanent supply of dissolved glucose. For the larger-scale storage of reserves, animals turn to fats, which are lipids, because they store more than twice as much energy per unit of mass; and, in addition, they are liquid in the cells, which makes them more compatible with the movements of the body. A human organism stores glycogen as a reserve of energy needed for no more than six hours [1-6].

The storage polysaccharides can be sub classified and see the Figure 2.

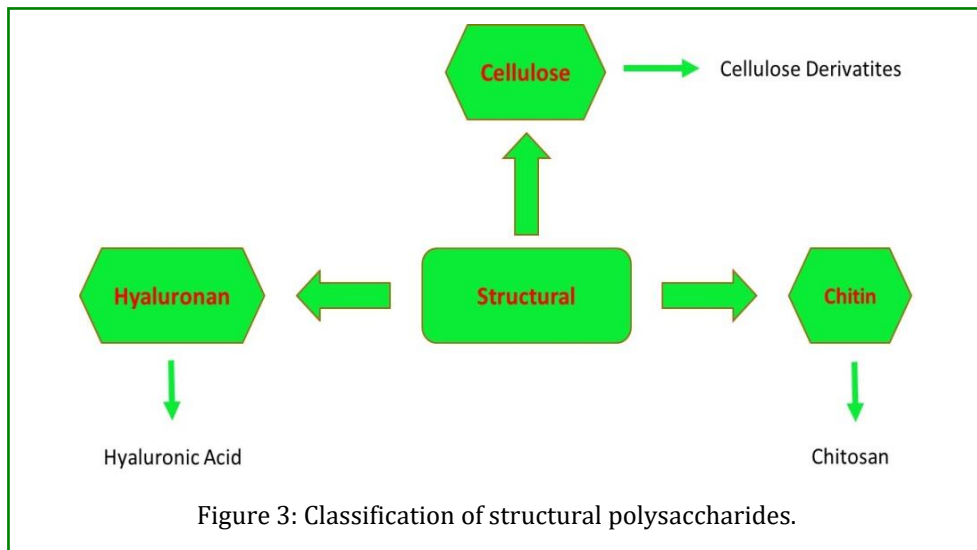


Structural Polysaccharides

These are carbohydrates that participate in the construction of organic structures. The most important are those that constitute the main part of the cell wall of plants, fungi and other eukaryotic osmotrophic organisms, they are fed by absorption of dissolved substances. These have no other more economical way to

support their body, than wrapping their cells with a flexible but resistant wall, against which they oppose the osmotic pressure of the cell, thus achieving a solution of the type that in biology is called hydrostatic skeleton [1,7].

The structural polysaccharides can be seen in Figure 3.



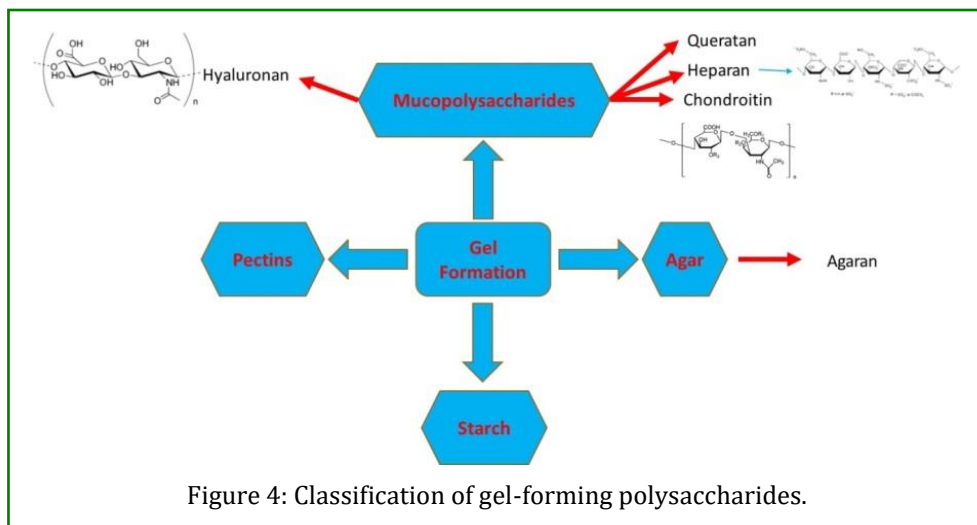
Gel Polysaccharides

Mucopolysaccharides are long chains of sugar molecules that are found throughout the body, often in the mucus and in the fluid around the joints. They are commonly called glycosaminoglycans [1,8].

Mucopolysaccharides are structural compounds of cartilage, bone, cornea, skin, walls of blood vessels, and

other connective tissues. They are carbohydrates that contain amino sugars and uronic acids. The best-known mucopolysaccharides are chondroitin-6-sulfate, heparin sulfate and keratin sulfate, which are excreted in the urine [1-10].

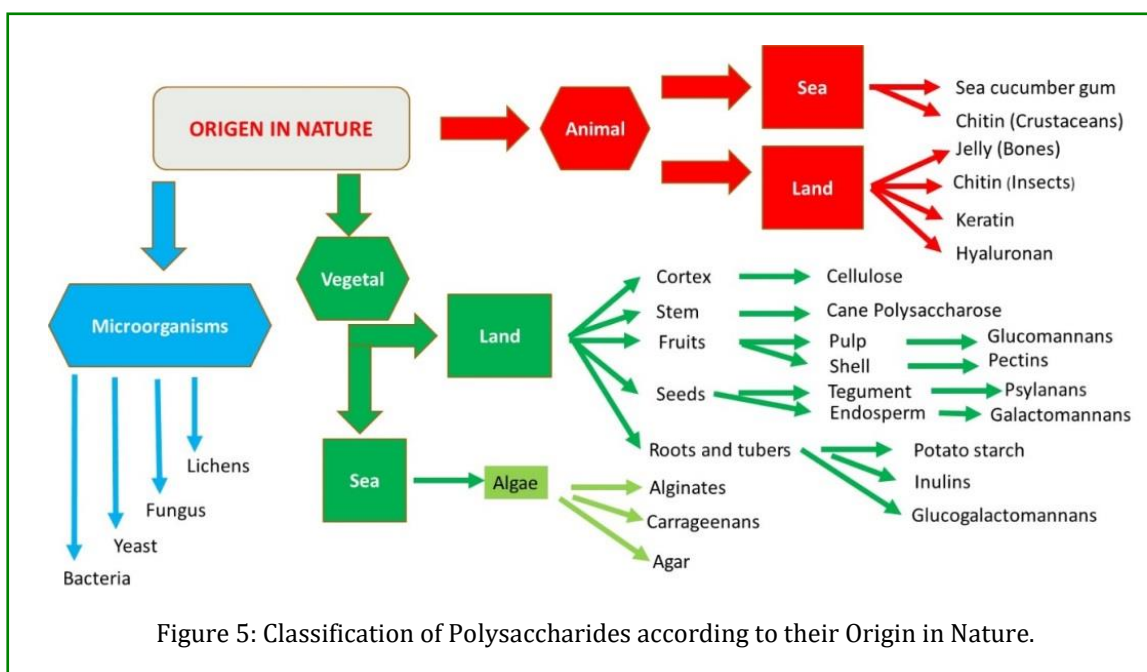
Those polysaccharides that form gels can be classified according to the Figure 4.



A polysaccharide gel is a colloidal system where the continuous phase is the polysaccharide and the dispersed is liquid, it can be water or some organic compound (ethanol, methanol, acetone, etc.). Gels have a density similar to liquids, however, their structure resembles more than that of a solid. A gel can contain a liquid in a proportion of 80% or more. The most common example of gel in polysaccharides is agar. Certain gels have the ability to move from one colloidal state to another, that is, they remain fluid when they are agitated and solidify when they remain motionless. This characteristic is called thixotropy. The process by which a gel is formed is called gelation. By replacing the liquid with gas it is possible to create aerogels, materials with exceptional properties such as very low densities, high porosity and excellent thermal insulation [1,11,12].

Polysaccharides According to their Origin in Nature

Polysaccharides are derived from a wide variety of sources: bacteria, fungi, algae and plants. Despite the many sources of polysaccharides, the world market is dominated by polysaccharides from algae and higher plants. These biopolymers are obtained by direct extraction of the biomass and can be subjected to chemical hydrolysis or fermentation to obtain the smallest molecules capable of being polymerized [1-4]. Another schematic form of classification is according to its origin or origin in nature, Figure 5.

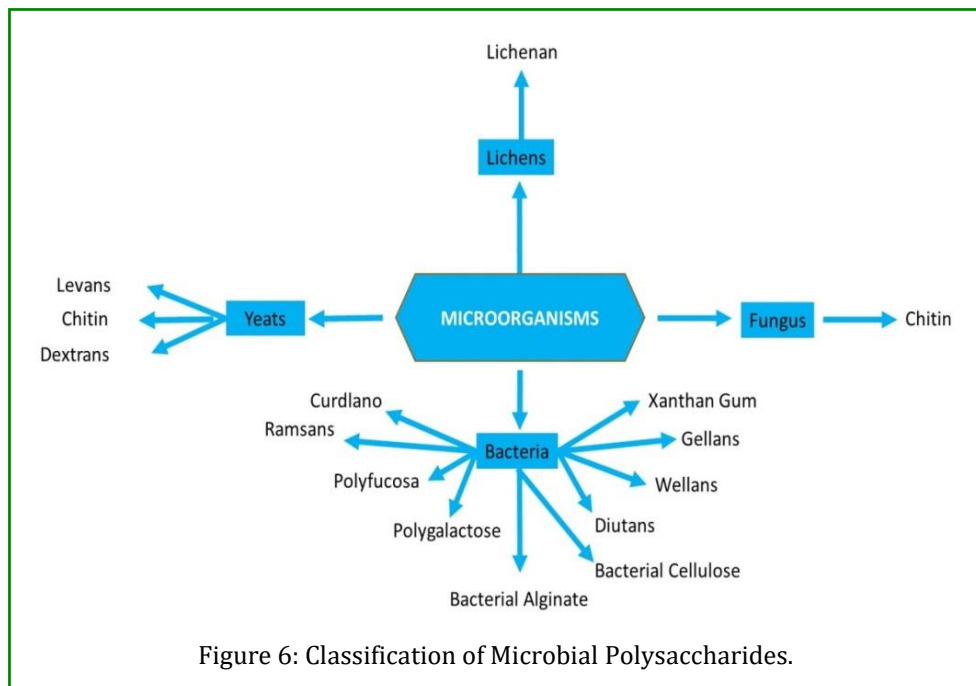


Polysaccharides of microbial origin

Polysaccharides derived from microorganisms, including bacteria, yeasts and molds, represent an untapped market. Polysaccharide biosynthesis and accumulation generally take place after the growth phase of the microorganism. The polysaccharides produced by microorganisms can be classified into three large groups according to their location in the cell: (i) cytosolic polysaccharides, which provide a carbon and source of energy to the cell; (ii) the polysaccharides that constitute the cell wall, including peptidoglycans, rooftop acids and lipopolysaccharides and (iii) the polysaccharides that are exuded in the extracellular environment in the form of

capsules or biofilm, known as exopolysaccharides (EPS). EPS are divided into two groups: homopolysaccharides and heteropolysaccharides. Homopolysaccharides are composed of a single type of monosaccharide, such as dextran and levan. Heteropolysaccharides are composed of several types of monosaccharides such as xanthans and gellans, have complex structures and are generally synthesized within the cell in the form of repetition units [1,12-14].

The microorganisms produce polysaccharides and are represented in Figure 6.



Plant or vegetable gums

Various parts of the plant (for example, cell walls of plants, tree exudates, seeds, tubers / roots, algae) have surface cells that contain gums, mucilages, and fiber and protein compounds [1]. Exudates gum plant are produced by several plants as a result of mechanical protection mechanisms or microbial lesions.

A number of fruits is also known to contain a remarkable amount of compounds diverse with respect to the level of structural and non-structural carbohydrates, depending on the fruit, its maturation period and the storage time. There are several examples such as mango (*Mangifera indica L.*, of the *Anacardiaceae* family), papaya (*Carica papaya L.*, of the *Caricaceae* family), plantain (*Musa acuminata*, the *Musaceae* family), carambola (*Averrhoa carambola L.*, of the family *Oxalidaceae*), and guava (*Psidium guajava L.*, of the *Myrtaceae* family). A considerable number of the seeds of legume plants and with vulva are the valuable sources of seed gums. In addition, there is a clear difference that applies to its structure and characteristics - from species to species. The considerably increased interest in rubber plant exudates is due to its various structural properties and metabolic functions in food, pharmaceutical, cosmetic, textile and biomedical products. Plant polysaccharides can be used as dietary fiber, texture modifiers, gelling agents, thickeners, emulsifiers, stabilizers, coating agents and packaging films. In recent years, the demand for

plant-based gums in food systems, medicines and drug delivery systems has increased considerably because they are the most notable ingredient in liquid and semi-solid foods [1-4].

Animal polysaccharides

The classic polysaccharides obtained from animals are chitin and the chitosan of insect and crustacean exoskeleton. Hyaluronic acid from animal skin. Finally, the mucopolysaccharides described above [1-3].

Ionic Polysaccharides

Anionic: they have carboxylate and carboxylic acid groups in their chain and have the characteristic of being weak acid and slightly acid.

Neutral: they have hydroxyl groups and pH close to 7.

Cationic: possess amino and amino acids groups in their chain and have the characteristic of being weak and slightly basic.

Polysaccharides According to your Application

Polysaccharides are used industrially as emulsifiers and coemulsifiers, thickeners, stabilizers and gelling agents in food products. More recently they have been used as decontamination agents and there is a growing interest in

their biological functions as antitumor, antioxidant or prebiotic activities [1-22].

References

1. Marta Izydorczyk, Steve W Cui, Qi Wang (2006) Polysaccharide Gums: Structures, Functional Properties, and Applications. Chapter 6, Taylor Francis.
2. Phillips GO, Williams PA (Eds.), (2009) Handbook of hydrocolloids. (2nd edn), CRC Press.
3. Stephen AM, Phillips GO (2006) Food polysaccharides and their applications. CRC Press.
4. Ronald EW (2012) Food Carbohydrate Chemistry. John Wiley & Sons, ISBN:9781118688496, DOI:10.1002/9781118688496.
5. Edible Films and Coatings for Food Applications (2009) In: Milda E, Embuscado, Kerry C, Huber (Eds.), Food Science & Nutrition, Springer.
6. Magdy M, Elnashar, Sciyo (2010) Biopolymers, Wiley Online Library.
7. Biopolymers utilizing Nature's Advances Materials (1997) In: (Eds,) Imam, Green, Zaidi, ACS Series 723.
8. Dumitriu S (2005) Polysaccharides: Structural Diversity and Functional Versatility. J Am Chem Soc 127(28): 10119-10119.
9. Nishinari K (1999) Physical Chemistry and Industrial Application of Gellan Gum. In Progress in Colloid and Polymer Science. In: F Kremer, Leipzig, G Lagaly, (Eds.), 1(14): Ed. Springer.
10. SF Sun (2004) Physical Chemistry of Macromolecules. Basic Principles and Issues. (2nd edn.). John Wiley & Sons, ISBN: 978-0-471-28138-2.
11. Kenji Kamide (2005) Cellulose and Cellulose Derivatives (1st edn.). Molecular Characterization and its Applications. Elsevier BV, pp 652.
12. Heinze T, Liebert T, Koschella A (2007) Esterification of Polysaccharides. J Am Chem Soc 129(7): 2195-2196.
13. Banerjee S, Bhattacharya S (2012) Food gels: gelling process and new applications. Crit Rev Food Sci Nutr, 52(4): 334-346.
14. Tako M (2015) The principle of polysaccharide gels. Advances in Bioscience and Biotechnology 6(1): 22-36.
15. Rinaudo M (1993) Gelation of polysaccharides. Journal of intelligent material systems and structures 4(2): 210-215.
16. Morris VJ (1985) Gelation of polysaccharides. Functional properties of food macromolecules 2.
17. Nishinari K, Takahashi R (2003) Interaction in polysaccharide solutions and gels. Current opinion in colloid & interface science 8(4-5): 396-400.
18. Nishinari K, Zhang H, Ikeda S (2000) Hydrocolloid gels of polysaccharides and proteins. Current opinion in colloid & interface science 5(3-4): 195-201.
19. Milani J, Maleki G (2012) Hydrocolloids in food industry In Food industrial processes-methods and equipment. Intech Open.
20. Eliasson AC (2006) Carbohydrates in food. CRC press.
21. Cui SW (2005) Food carbohydrates: chemistry, physical properties, and applications. CRC press, ISBN 9780849315749.
22. Food Science and Technology (1998) International Series. Steve Taylor. Academic Press.