powder for several months in a cool, dry place and away from sunlight. However, the shelf life can be increased for several years by storing it in a freezer. Sodium salt of ALG is more stable than its acidic form, which can degrade rapidly. The reason for this rapid degradation rate of alginic acid is thought to be intramolecular catalysis by the C-5 carboxyl groups [25].

1.5 Sources

Alginate is extracted from the brown seaweeds by methods that can convert the insoluble ALG (present in the seaweed cell walls as calcium and magnesium ALG) to a soluble form, usually sodium ALG during extraction [26]. Different seaweeds used for extraction of ALGs are *Laminaria digitata, Laminaria brasiliensis, Sargassum filipendula, L. hyperborean*, and *M. pyrifera*. Worldwide ALG is derived from various industrial sources like from *Macrocystis* from the USA, *Laminaria* and *Ascophyllum* from Northern Europe, *Durvillaea* in Australia and Chile, and *Sargassum* and *Turbinaria* in India, the Philippines, and other tropical countries.

1.6 Biosynthesis of Bacterial Alginate

P. aeruginosa has been studied first by Darzins and Chakrabarty (1984) by using complementation studies for the genes involved in the production of ALGs. Till now, at least 24 genes have been identified in *P. aeruginosa*, which are directly involved in production of ALG. Chitnis and Ohman (1993) proposed that all the structural genes involved in ALG biosynthesis are clustered in a single operon except algC. There are 12 genes in the cluster, namely algD, alg8, alg44, algK, algE, algG, algX, algL, algI, algJ, algF, and algA, which are located at approximately 3.96 Mb on the PAO1 genome map. The promoter is located upstream of algD, which tightly regulates the operon.

Pindar and Bucke, in 1975, proposed the first bacterial ALG biosynthesis pathway in *Azotobacter vinelandii*. They studied that ALG is first synthesized as a linear homopolymer of D-mannuronic acid residues. The process can be broken down into four stages: (1) precursor synthesis, (2) polymerization and cytoplasmic membrane transfer, (3) periplasmic transfer and modification, and (4) export through the outer membrane.