1.6.3.2 Mannuronan C 5-Epimerases

Epimerization of the D-mannuronate to L-guluronate is catalyzed by AlgG at the polymer level [35]. This epimerization process modifies the structural properties of ALG, including its gelling ability and its ability to bind divalent ions such as calcium. Recently, six different C5-epimerase encoding genes have been identified in the genome of *L. digitata* [43].

1.6.3.3 Lyases

The ALG lyases, also known as ALG depolymerases or alginases, catalyze the β-elimination reaction, which leads to degradation of ALG. It functions as an editing enzyme in ALG-producing bacteria, controlling the length and the molecular weight of the polymer. These enzymes have different residue specificities and cellular localizations. Among *Pseudomonas* species, PA1167 is identified as one other protein to have ALG lyase activity. The epimerase AlgE7 and three others, AlyA1, AlyA2, and AlyA3, are the four lyases that have been identified among *Azotobacter* species.

1.6.5 Export through the Outer Membrane

Alginate is secreted through a putative porin known as AlgE (called AlgJ in *Azotobacter*). It forms an anion-selective pore through the outer membrane, and the pore is partially blocked by GDP-mannuronic acid. Homology modeling showed that the protein is a β-barrel consisting of 18 antiparallel β-strands with 8 periplasmic and 9 surface-associated loops. This protein is responsible for the secretion of intact ALG and can be detected in the outer membrane of mucoid, ALG-overproducing strains of *P. aeruginosa* but is absent in non-mucoid strains.

1.7 Conclusion

Alginates are naturally occurring anionic polysaccharides, which are present as a structural component in brown algae. They consist of linear biopolymers consisting of 1,4-linked β-D-mannuronic acid (M) and 1,4 α-L-guluronic acid (G) residues arranged in homogenous (poly-G, poly-M) or heterogenous (MG) block-like patterns. The pattern of residues determines the physicochemical properties of ALGs. Alginate has an excellent functionality as a thickening agent, gelling agent, emulsifier, stabilizer, texture improver, and many more. Due to these qualities, ALGs have various