Softening is one of the main reasons for quality loss of fruit and vegetables which influences storage life, transport ability and diseases resistance. Texture of fruit and vegetables is fundamentally related to their structure, of which the cell wall polymers form the basic structural units. Studies showed that plant cell walls (PCW) owe its macroscopic properties due to formation of a fiber network, where the strength of adhesion between cellulose fibers and between cellulose and the surrounding polymer matrix is a key determining factor of the wall network mechanics.

Although the role of inter-fiber links in plant cell walls is commonly recognized, no direct measurements of the adhesive forces between nanoscale cellulose fibers have yet been reported. Furthermore, there is little known about the mechanistic details of the role of hemicelluloses in the structure and energy of adhesive contacts between cellulose fibers. Currently, the most reliable information regarding inter-fiber adhesion is inferred from the macroscopic mechanical properties of cellulose networks such as bacterial cellulose plant cell wall analogues and their microscopic structural analysis. However, with lack of numerical model of fiber network mechanics deducing the nature of interaction between cellulose fibers and other PCW polysaccharides presents a significant challenge.

Revision of the cellulose-cellulose and cellulose-hemicellulose fiber interaction in plant cell walls needs elaboration of new approach based on multiscale-scale robust experimental methods supported by computational modeling tools. Therefore in this project we propose study the hemicellulose-cellulose fibrous networks using well established analogues of plant cell walls based on cellulose synthetized by bacteria in hemicellulose-rich medium with aid of modern numerical modeling techniques to simulate properties of obtained structures of the networks.

In this regard cellulose-cellulose and hemicellulose-cellulose interactions will be studied by utilizing model systems consisting of bacterial cellulose (BC) and hemicelluloses, which has been considered to be structural analogues of plant cell walls. Considerable progress in understanding the mechanics and properties of plant cell walls will be achieved by means of the modern experimental and theoretical methods, such as atomic force microscopy (AFM) and numerical simulations.

In this study a multi-scale and bottom-up approach is proposed - structural and mechanical characterization starting from a single fibers up to a bacterial cellulose fiber network of plant cell wall analogue. Similar to hemicellulose compounds, the bacterial cellulose will be characterized structurally and mechanically by means of AFM. Atomic force microscopy will be also used to investigate the process of incorporation of hemicellulose into bacterial cellulose network. Following the same path, the multi-scale modelling approach will result in development of numerical and statistical tools for description of the structure and behavior of PCW at many spatial scales – from single fiber to whole fiber network. The result of the project will be new knowledge about the physical properties of cellulose-hemicellulose interactions and properties fibrous networks of plant cell walls, especially the mechanism of incorporation of hemicellulose into cellulose network.