

Understanding and evidencing of the Hard to Cook phenomena and its impact in red beans (*P. Vulgaris*) for industrial processing optimization

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In recent years, the Hard to Cook (HtC) development in beans has seen the surge of a reticence for the consumption of legumes : a high nutritional and environmental value matrix. Every single one of these hypotheses found in literature converges into a correlation between the quantifiable consequences of HtC and the thickening of the middle lamella and/or the cellular wall. This rigidification is majorly due to detrimental storage conditions (high humidity, temperature). For a better understanding of this phenomenon, it is essential to precisely study the behavior of beans during traditional preparation (soaking, cooking). Highlighting of water transfers in beans during cooking, link with structural modification of the matrix, gelatinization of the starch, modification of the pectinic walls and evolution of the texture should allow a better control of cooking.

The resolution strategies focus on (i) the understanding of the physical, chemical and biochemical mechanisms, through an adapted experimental metrology and analyses dedicated to the product and (ii) the application of an experimental methodology to determine the optimal operating parameters. Structural modifications and thermal behavior were characterized by a correlation of DSC profiles and MEBE observation.

The aging of beans modifies the internal structures and thus the kinetics of water uptake during soaking, as well as the direction of the cooking gradients inside the cotyledons. Soaking temperatures change the state of the pectin walls and the water accessibility of the bagged starch in the plant cells. The destructure of the matrix occurs in two steps during cooking, with a two-step gelatinization of the starch. A heat treatment in excess of water is necessary to depolymerize the cell wall compounds and make the starch accessible. The time and temperature of soaking, as well as the condition of the bean before processing, have a strong impact on its cooking time and final characteristics.

The microstructure of the beans was shown to have an impact on their density and water holding capacity. A database gathering the data collected in this project has made it possible to develop densimetric and NIR sorting methods to predict the cooking behavior of different batches.