Modeling Alpha Galactosides Behavior During Cowpea Soaking Cooking for Nutritional Optimization

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Abstract

Cowpea seed is a pulse which is very rich in vital micronutrients but also in anti-nutritional factors such as α-galactosides (verbascose, stachyose and raffinose) that can cause digestive disorders after consumption. The objective of this work was to identify the transport and reactivity properties of α-galactosides as a function of soaking-cooking process conditions (time, temperature, etc.) to reduce their content in seed. A 3D single-seed being surrounded by a limited amount of soaking water was modelled using the COMSOL Multiphysics® software. Six combined Partial Differential equations (three in the seed domain and three others in the soaking water medium domain) describing simultaneously the diffusion and degradation-production chain reaction of alpha-galactosides were written using the COMSOL PDE mode and solved numerically with the COMSOL time-dependent solver. The resulting model was adjusted (minimizing the root-mean-square error) to experimental data considering alpha-galactosides kinetics both in seed and soaking medium at 30°C, 60°C and 95°C with a seed-to-water ratio of 1:4 (w/w). In total, 9 parameters were adjusted and identified for each considered temperature. The 95% confidence intervals were obtained by means of Monte Carlo method using LiveLink for MATLAB®. At 95°C, α-galactosides were not thermally degraded since adjusted rate constants were null. Degradation rate constants k identified in the seed at 30°C for stachyose (2.90 ± 1.5×1e-6 1/s) and raffinose (5.80 ± 3.0×1e-6 1/s) were consistent regarding their respective Michaelis constants. These reactions may be attributed to the action of cowpea endogenous α-galactosidase. Shifting from 30°C to 60°C induced an important decrease of α-galactosides rate constants. For instance, in soaking water, k for stachyose was about 13 times lower (0.12 ± 0.08×1e-4 1/s) at 60°C than at 30°C (1.61 ± 0.7×1e−4 1/s). This can be explained by the fact that optimal temperature for α-galactosidase activity is around 35°C. In terms of mass transport, α-galactosides molecular diffusivity increased with soaking temperature. As an example, raffinose apparent diffusivity in seed shifted from 0.88 ± 0.9×1e-11 m2/s (30°C) to 4.64 ± 3.9×1e−11 m2/s (95°C). To go further, it is worth investigating and modelling the activity of cowpea endogenous enzymes as a function of processing conditions to know if an appropriate presoaking step could maximize the degradation rate of α-galactosides, and this work is now underway. The resulting simulator can be used to identify processing pathways that could minimize cowpea α-galactosides content.