

María Beatriz Sousa · Wenceslao Canet ·
María Dolores Alvarez · María Estrella Tortosa

Effect of processing on the texture and structure of raspberry (cv. *Heritage*) and blackberry (cv. *Thornfree*)

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Abstract This paper reports separate studies of the effect of pre-treatments (CaCl_2 , low methoxyl pectin (LMP), and combined solutions) and the effect of freezing method (at four different rates) and thawing mode (at two different rates) on objective parameters, structure and sensory characteristics of fresh raspberries and blackberries. After that, the effect of a complete freezing process combining the best pre-treatments with the best freezing/thawing conditions found for each fruit was investigated. Kramer Shear Cell (KSC), back extrusion, compression and multiple penetration tests were used to measure fruit texture objectively. For calcium and LMP pre-treatments, which were applied separately, texture parameters were significantly higher in samples treated at the highest concentrations (100 mM of CaCl_2 for both fruits and 0.3 and 3% of LMP for raspberry and blackberry, respectively) compared to fresh controls. Blackberry structure was more susceptible than raspberry structure to the effect of pre-treatments. For the combined pre-treatments, the highest texture parameters were found in the samples treated with CaCl_2 (100 mM) and LMP (0.1%) in the case of raspberries and CaCl_2 (100 mM) and LMP (3%) in the case of blackberries. Combined pre-treatment did not increase firmness with respect to that of samples treated only with calcium, which indicates that

CaCl_2 preserved the raspberry structure more efficiently during processing. Fruits frozen by forced convection with liquid nitrogen vapour at -40°C were significantly firmer. Raspberries should be thawed at 5°C , whereas blackberries may be thawed at room temperature. Sensory analysis showed that the blackberry structure was more resistant to freezing. In both fruits, over the complete process parameter values were again highest in the samples treated with 100 mM CaCl_2 , applied either separately or in combination with LMP. In raspberry, panellists detected no significant differences between sensory texture parameters of the different samples, and in blackberry, panellists found no significant differences between any of the sensory characteristics. Multiple penetration maximum force (F_{MP}) was the parameter that best expressed product firmness for both fresh and frozen raspberries, whereas compression slope (S_{C}) best reflected changes in blackberries. SEM mainly corroborated results from objective texture parameters.

Keywords Raspberry · Blackberry · Protective pre-treatments · Freezing and thawing rates · Texture · SEM · Sensory analysis

M. B. Sousa
Departamento Tecnologia dos Produtos Agrários, Estação
Agronómica Nacional,
Quinta do Marquês,
2784-505 Oeiras, Portugal

W. Canet · M. D. Alvarez (✉)
Department of Plant Foods Science and Technology, Instituto
del Frío-CSIC,
José de Novais no.10,
28040 Madrid, Spain
e-mail: ifrat44@if.csic.es
Tel.: +34-91-549-23-00
Fax: +34-91-549-36-27

M. E. Tortosa
Department of Plant Biology, Escuela Técnica Superior de
Ingenieros Agrónomos, U.P.M., Ciudad Universitaria s/n,
28040 Madrid, Spain