Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 150 (2015) 200–206

Contents lists available at ScienceDirect

Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy

journal homepage: www.elsevier.com/locate/saa

In situ study of water uptake by the seeds, endosperm and husk of barley using infrared spectroscopy

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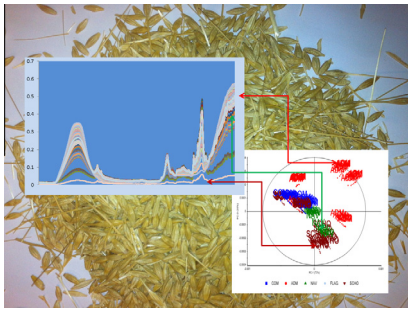
HIGHLIGHTS

- Attenuated total reflectance was used to assess in situ and non-destructively water uptake.
- Different patterns in the mid infrared spectra of different barley varieties were observed.
- Calibrations for water uptake were obtained for each variety using mid infrared.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 16 February 2015
Received in revised form 14 May 2015
Accepted 24 May 2015
Available online 29 May 2015

Keywords:
Barley
Water uptake
Mid infrared
Attenuated total reflectance

ABSTRACT

Variations in the amount and rates of water uptake influence the seed hydration as well as the modification of the endosperm for industrial uses (e.g., malting). The aim of this study was to investigate and interpret absorption frequencies in the mid infrared (MIR) region associated with water uptake in whole seeds, husk and endosperm of barley seeds during the initial period of soaking in water. Partial least squares (PLS) regression models for the prediction of water uptake in the set of samples yield a coefficient of determination (R^2) and a standard error in cross validation of 0.75 and 2.57 (% w/w), respectively. The biological implications of this study are that the first stages of germination can be monitored using the information derived from the MIR spectra. These results also demonstrated that whole seeds, endosperm and husk derived from the same variety or genotype have different patterns in the MIR region.

Introduction

Kernel morphology and chemical composition (e.g., protein, starch, lipids and cell wall components), genetics, and environmental factors influence the water uptake by the seed/-grain of different cereals during the initial hours of soaking in water [1]. Variations in both the amount and rate of water uptake by the seed might lead to inefficient hydration and therefore to over or under modification of the endosperm for industrial uses (e.g., malting) [1,3,4,7,9].

The uptake of water by barley seeds is an essential and initial step towards germination [1,3,4,7,9]. This step is of importance not only for the direct effect on crop germination but also from a technological point of view (e.g., in the malting process it is often referred to as steeping) [4,7,9].

Abbreviations: ATR, attenuated total reflectance; MIR, mid infrared; NMR, nuclear magnetic resonance; NIR, near infrared; PC, principal component; PCA, principal component analysis; PLS, partial least squares; PRESS, prediction residual error sum of squares; R^2, coefficient of determination in cross validation; RPD, residual predictive deviation; RWU, rate of water uptake; SD, standard deviation; SECV, standard error of cross validation.

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http://dx.doi.org/10.1016/j.saa.2015.05.073
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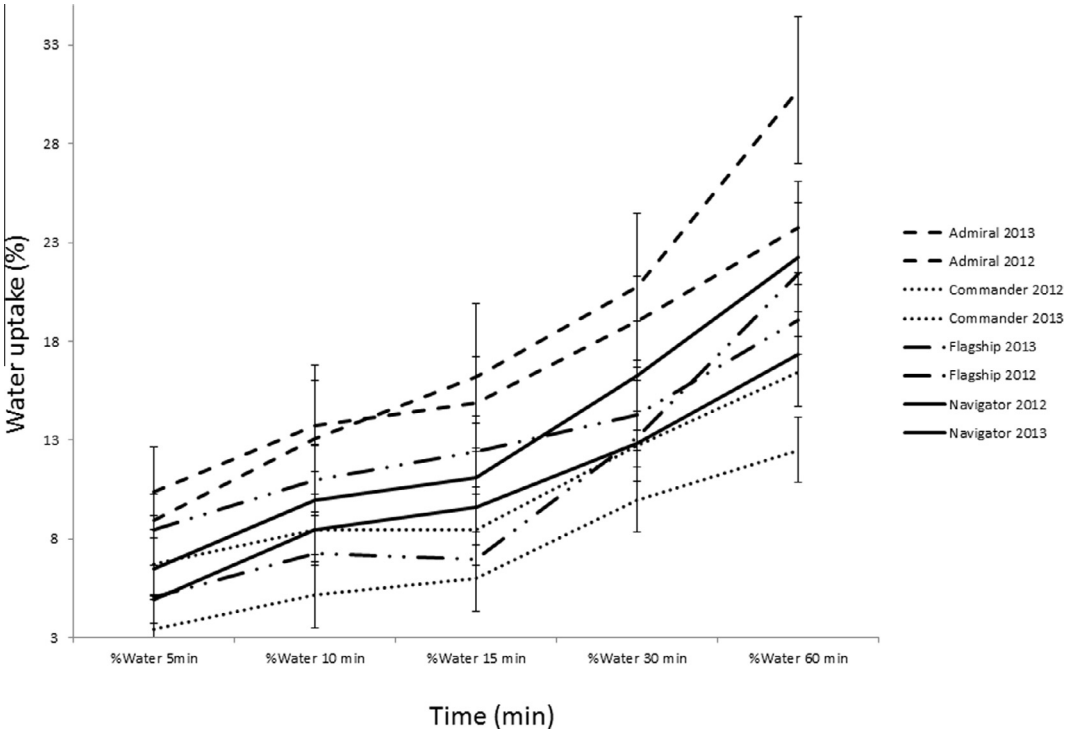

Fig. 1. Time course of water uptake in whole barley seed samples from different genotypes measured gravimetrically.

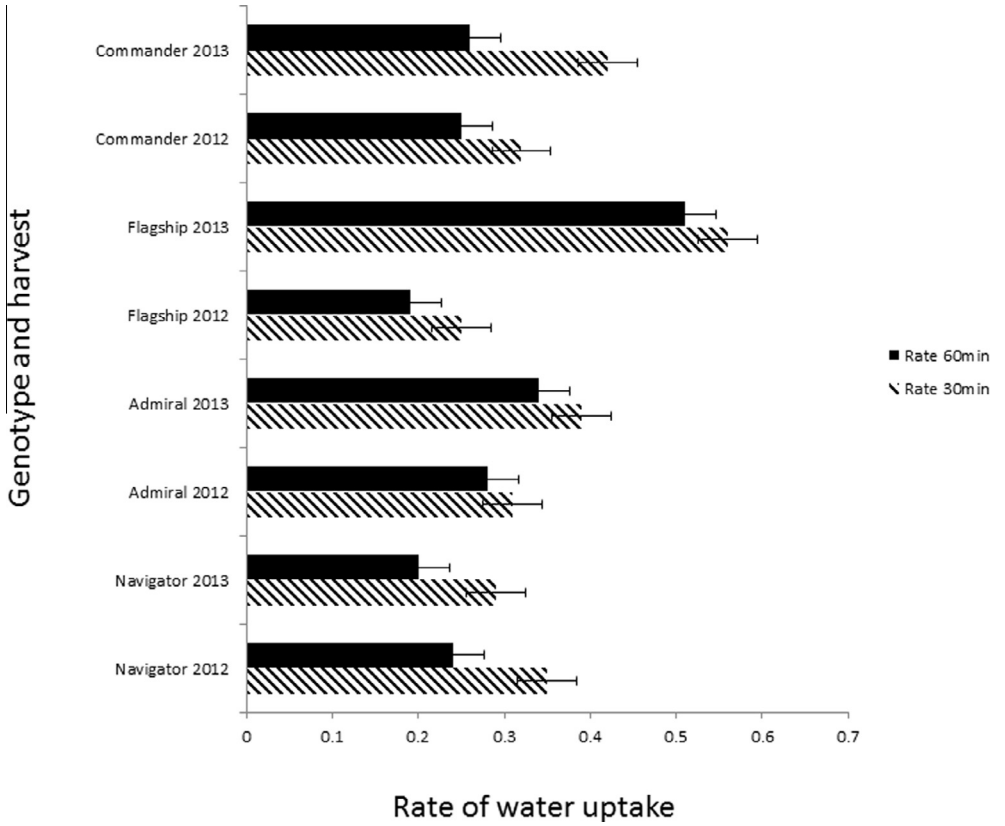

Fig. 2. Comparison of the rate of water uptake in different barley varieties from two consecutive harvests.

Most of the studies related with the water uptake by the seed of cereals are destructive in nature and require monitoring several samples due to the variations found between seeds, even within the same batch or lot [10,17,20]. Following changes non-destructively in the same seed throughout the imbibition procedure (a repeated-measure approach) has distinct advantages as