International Journal of
Food Science & Technology

www.ifst.org

Original article

Chemical and microstructural evaluation of 'hard-to-cook' phenomenon in legumes (pinto bean and small-type lentil)

Mansoureh Pirhayati, Nafiseh Soltanizadeh & Mahdi Kadivar*

Department of Food Science, College of Agriculture, Isfahan University of Technology, Isfahan 84156, Iran

(Received 17 February 2011; Accepted in revised form 28 May 2011)

Summary Some physicochemical and microstructural characteristics of hard-to-cook (HTC) and easy-to-cook (ETC) pinto beans and small-type lentils were compared. The development of HTC seeds was monitored over 6 months for changes in physicochemical properties. Results indicated that hardness, extent of water absorption and solid loss of HTC legumes were, respectively, 21–97%, 7–72% and 62–236% higher than those of ETC legumes. In addition, darkening of HTC beans and lentils was significantly higher than those of ETC ones. Scanning electron microscope observations indicated deteriorations in cytoplasmic contents of cotyledon cells of hard seeds. Phytic acid and total phenolic contents were, respectively, decreased 36–61% and 43–61% during storage, whereas hardness of seeds was increased 3–6 times. The soaking of hard seeds in sodium solutions resulted in the improvement in legume texture.

Keywords Bean, hard-to-cook, lentil, microstructure, phenolic compounds, texture.

Introduction

Legumes are cultivated all over the world as main or subordinate crop. Only 18 species of approximately 80 different legumes are widely cultivated worldwide, and among them, common bean (*Phaseolus vulgaris*) and lentil (*Lens culinaris*) are the most important species (Shehata, 1992). Legume seeds are a major source of dietary protein and fibre, starch, vitamins and minerals. However, they also contain several antinutritional factors that could easily be eliminated or reduced using techniques such as soaking, dehulling, heating (boiling in water, infrared radiation and extrusion), fermentation and sprouting (Fasina *et al*., 2001; Siddhuraju *et al*., 2002). Seed size, ripening degree, environmental and genetic factors as well as storage under adverse conditions may result in a phenomenon called 'hard-to-cook' (HTC) defect, which means seeds will not soften sufficiently during soaking and do not become tender after a reasonable cooking time (Bhatty, 1988; Liu & McWatters, 1994). Therefore, HTC seeds need additional energy during preparation and may have inferior nutritional qualities (Nasar-Abbas *et al*., 2008).

Poor cooking quality has been related to both shell and HTC defects. Hard shell may be attributed to impermeability of the seed coat to water, whereas HTC characteristic is attributed to the inability of cotyledon to be hydrated during cooking (Shehata, 1992). Generally, two types of hard shell have been noticed: the first type is reversible, particularly in freshly harvested crop, and the second one is irreversibly developed during storage.

According to Hentges *et al*. (1991), irreversible hard shell was created in common bean by storage at high temperature and low relative humidity (RH). Shehata (1992) observed a condition where some beans even did not hydrate during soaking despite scarification or removal of seed coats. This phenomenon, in which the cotyledon does not absorb water while the seed coat is permeable, was called 'sclerema' and was attributed to enzymatic activity during storage at high temperature and high RH. Reyes-Moreno *et al*. (2000) and Nasar-Abbas *et al*. (2008) described that extended storage at high temperature and humidity has been associated with the development of HTC defect in some legume varieties. Several mechanisms are proposed for HTC defect in legume seeds including: (i) lipid oxidation and/or polymerisation; (ii) autolysis of cytoplasmic organelles, weakling plasmalemma integrity and lignifications of middle lamella; (iii) phytin catabolism and pectin demethylation with subsequent formation of insoluble pectate; and (iv) interactions of proteins and polyphenols and polymerisation of polyphenolic compounds (Maurer *et al*., 2004).

Another phenomenon that may be involved in HTC defect is the formation of new interactions between cell

*Correspondent: E-mail: kadivar@cc.iut.ac.ir

doi:10.1111/j.1365-2621.2011.02697.x