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DENATURATION OF WHEY PROTEINS OF MILK DURING OHMIC HEATING

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KEYWORDS

Ohmic heating, β-lactoglobulin, electrophoresis

ABSTRACT

Ohmic heating has often been said to improve the sensorial quality of foodstuffs, which has been attributed mainly to its volumetric heating mechanism and (eventually) to the presence of an electric field. This is still subject to doubts and questions from the scientific community, and it is therefore important to determine the effect of ohmic heating on food constituents. We have investigated whether ohmic heating technology would give rise to changes on the denaturation of whey proteins from bovine milk. Whey protein solutions samples were heated at 85 ºC (up to 30 min) and ohmic heating experiments were also adapted to simulate the sample temperature changes during conventional (indirect heating) experiments. Our results show that ohmic heating seems to reduce protein unfolding and denaturation, when compared with conventional heating.

INTRODUCTION

Ohmic heating (OH) is now receiving increasing attention from the food industry, once it is considered to be an alternative for the indirect heating methods of food processing (Castro, Macedo et al. 2004; Pereira, Pereira et al. 2007) During OH treatment electric currents are passed through foods, which behaves as a resistor in an electrical circuit, and heat is internally dissipated according to Joule's law (De Alwis and Fryer 1990). The major benefits claimed for ohmic heating technology are the continuous processing without heat transfer surfaces, uniform heating of liquids and, under certain circumstances, heating of solids and carrier fluids at very comparable rates, thus making it possible to use High Temperature Short Time (HTST) technique (Knirsch, Alves dos Santos et al. ; Parrot 1992; Imai, Uemura et al. 1995). For all these reasons, OH seems to allow obtaining value added products of a superior quality without compromising food safety (Parrot 1992; Castro, Teixeira et al. 2003; Tucker 2004; Machado, Pereira et al. 2010). Milk proteins are probably the most affected constituents by heating and some of the changes may involve interaction with sugars, aggregation of casein micelles or association of whey protein aggregates with casein micelle surface through formation of the β-lactoglobulin – κ-casein complex. However, very limited information is available on the effects that ohmic heating and the presence of moderate electric fields during heating may have on denaturation and association of milk proteins. The aim of this work is to evaluate the denaturation of the main whey proteins of bovine milk, such as β-lactoglobulin (β-Lg) and α-lactalbumin (α-Lac) during ohmic heating.

RESULTS AND DISCUSSION

OH treatments were performed in a bench-scale ohmic heater (Fig. 1). Extreme care was taken to simulate the conventional thermal history of the samples (Fig. 2).

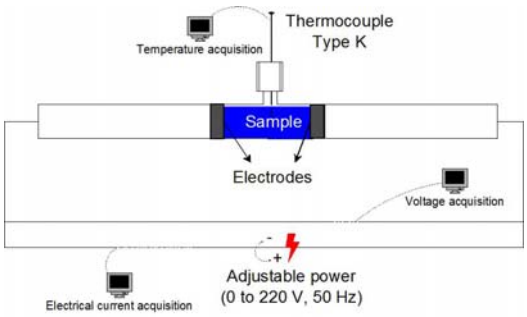

Figure 1 - Bench-Scale Batch Ohmic Heater

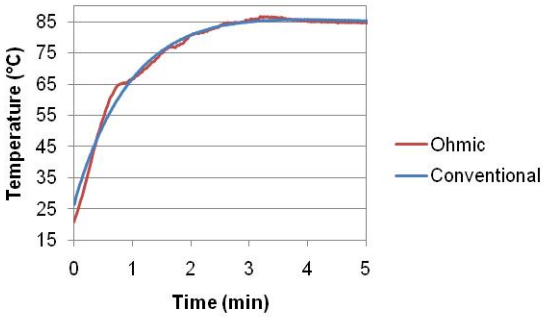

Figure 2 - Example of Similar Thermal Histories at 85 ºC for Conventional and Ohmic Heating

Precipitation of denaturated whey proteins at pH=4.6, allowed quantification of native proteins (Parris and Baginski 1991) through high-performance liquid

chromatography (HPLC) after conventional and ohmic heating treatments at 85 °C and 30 s of holding (Fig. 3)

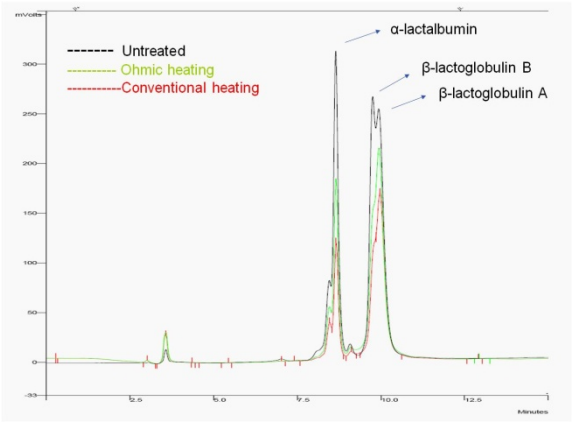

Figure 3 - Examples of HPLC Chromatograms after Conventional and Ohmic Heating of Whey Protein Isolate Solutions (WPI)

Denaturation of whey proteins in whey solutions was also evaluated through native Polyacrylamide Gel Electrophoresis (PAGE) (Fig. 4). While in SDS-PAGE the electrophoretic mobility of proteins depends primarily on their molecular mass, in native PAGE the mobility depends on both the protein's charge and its hydrodynamic size.

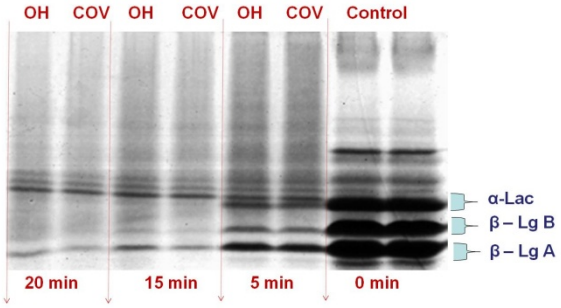

Figure 4 - Native PAGE Bands of β-Lactoglobulin (A and B variants), and α-Lactalbumin during Ohmic (OH) and Conventional (COV) Heating at 85 ºC

Results from HPLC and native PAGE have shown that β-lactoglobulin and lactalbumin were less denaturated when ohmic heating was applied. Smaller loss of native whey protein during ohmic heating was observed, when compared with conventional heating. At the end of 5 min, ohmic heated WPI solutions presented about 6 % and 2 % more native β-Lg and α-Lac, respectively, than WPI solutions heated conventionally.

CONCLUSIONS

The results presented here suggest that the ohmic heating influence mechanisms of denaturation. The absence of hot surfaces and its volumetric heating mechanism may have contributed to a lower denaturation of α-Lac and β-Lg. Ohmic heating may have consequences on the acid-induced gelation properties of milk and thus influence the functional properties of dairy products

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RICARDO N. PEREIRA was born in Porto, Portugal and graduated in Food Engineering in 2003 by the Portuguese Catholic University, in Porto, Portugal. His main research interests are food processing by ohmic heating/moderate electric fields and pulsed electric fields. He is presently PhD student at the Engineering School of the University of Minho, in Braga, Portugal.