Chemical and Structural Changes in White Sauces Thawed by Microwave or Conventional Oven

*L. M. GUARDEÑO, E. LLORCA, I. PÉREZ-MUNUERA, A. QUILES and I. HERNANDO**

*Grupo de Microestructura y Química de Alimentos, Departamento de Tecnología de Alimentos, Universidad Politécnica de Valencia, 46022 Valencia, Spain. *E-mail: mihernan@tal.upv.es*

Abstract: Proteins, lipids and structural changes in white sauces after being stored at –18°C and thawed by microwave and conventional oven were studied in this work. The total crude and soluble protein fractions were quantified by N-Kjeldahl. The acidity grade and oxidation spectrophotometric parameters (k_{232} and k_{270}) were used to analyse the lipid fraction. In addition, confocal scanning laser microscopy (CSLM) was used to study the structure of the sauce. The results showed that the total crude protein fraction increased in the thawed samples if compared to the freshly-prepared samples, mainly when microwave oven was used. However, the soluble protein fraction did not vary significantly ($P < 0.05$) among the different samples. Regarding the lipid changes, the acidity index did not show significant differences among the samples. K_{232} values of the microwave-thawed samples differed significantly from the freshly-prepared and the conventional-thawed samples. Furthermore, k_{270} values were significantly different between the samples thawed using the conventional oven and the freshly-prepared ones. CSLM images showed degradation of the starch granules and an increase of size in the fat globules due to thawing.

Keywords: sauce; microwave; thawing; microstructure; CSLM; chemical changes

INTRODUCTION

Nowadays, ready-to-eat meals have consolidated as a common option to eat, due to the lack of time for cooking. The use of microwave oven (MO) has risen as a quick method to prepare, thaw or reheat foodstuffs. The effects of microwave heating on the food components can differ from those produced by conventional heating. The main studies relating the effects of microwave to changes on food components have been found on oils (Albi *et al*. 1997; Yoshida *et al*. 2003; Malheiro *et al*. 2009). It has been speculated that free radicals can be formed by exposure to microwave energy (Albi *et al*. 1997) and it was found that the rate of oxidation, depends on the polyunsaturated fatty acid content (Hassanein *et al*. 2003).

Regarding microstructure, there are some studies about the effect of microwaves on textural and microstructural properties of starch-water model systems (Palav & Seetharaman 2006; Bilbao-Sáinz 2007). Differences in gelatinisation process under conventional or microwave heating are analysed in these studies. However, there is a lack of information about the effect of microwaves on other food matrices.

The objective of this study is to investigate differences on chemical and microstructural characteristics of white sauces under different thawing methods.

MATERIALS AND METHODS

Materials and sample preparation. The white sauce consisted of modified waxy corn starch (3.5%w/w) (hydroxypropyl distarch phosphate, Polar Tex 06748, Cargill, Inc., USA), τ-carrageenan (0.50% w/w) (Secovis IS, Hispanagar, Burgos, Spain), skimmed milk powder (9.30% w/w) (Central Lechera Asturiana, Asturias, Spain), sunflower oil (2.55% w/w) (Koipesol, SOS Cuétara S.A., Madrid, Spain), sodium chloride (0.40% w/w) (Panreac

Química SAU, Barcelona, Spain) and water up to 100% w/w. Samples were prepared according to Arocas *et al*. (2009). Samples (300 g) were frozen at –18°C for a week. A batch of samples was thawed in a microwave oven (Moulinex Optimo, Paris, France) at 700 W for 6 min, and another batch was thawed in a conventional oven (Fagor 2CF-3V, Guipúzcoa, Spain) at 220°C for 30 min, until the samples were totally thawed.

Protein fraction. Both crude and soluble protein were determined by Kjeldahl procedure (AOAC 1998). The extraction of soluble nitrogen fraction was performed from the lyophilised sample by Kuchroo and Fox (1982) modified method. Three centrifugation cycles at 10 000 rpm were carried out at 4°C.

Lipid fraction. The acidity index was determined according to AOAC (1998), and k_{232} and k_{270} parameters were determined by spectrophotometric analysis (UNE 1973).

Confocal scanning laser microscopy (CSLM). A drop of the sample was put on a slide and stained with Rodhamine B (2 g/l) and Nile Red (1 g/l) solutions. Then, the mixture was covered with a cover glass. The samples were observed in a CSLM (Nikon confocal microscope C1 fitted to a Nikon Eclipse E800 microscope, Nikon Co., Ltd., Tokyo, Japan) in single photon mode equipped with an Ar-Kr laser. The excitation wavelength and emission maxima of the applied fluorescent dyes were 568/625 nm for Rhodamine B and 647/675 nm for Nile Red. Images were stored using EZ-C1 software (Nikon Co., Ltd., Tokyo, Japan).

Statistical analysis. The statistical analysis was carried out by ANOVA and the least significant differences (LSD) were calculated at significance level $P < 0.05$. The statistics software Statgraphics Plus version 5.1 (Manugistics, Inc., Rockville, USA) was used.

RESULTS AND DISCUSSION

Table 1 shows the values of the parameters measured in the fresh and thawed sauces. The results show that total protein crude fraction increased when samples were thawed. This increase was significant in samples thawed in the microwave oven (MO) due to the evaporation of water. The internal temperature gradient generated in microwave heating forces the moisture to transfer to the surface (Meda *et al.* 2005) favouring water evaporation. In the conventional oven (CO), the high temperature at the surface of the product leads to dehydration and forms a crust that could limit this evaporation. The soluble nitrogen fraction was not significantly different in samples thawed by both methods if compared to fresh ones; so, thawing did not cause changes in the solubility of proteins. Regarding to lipid changes, significant differences were not found among the samples when acidity index was analysed. This indicates that not evident lipolysis is produced in the samples during thawing using MO or CO. k_{232} and k_{270} parameters mainly indicate the conjugation of trienes and the presence of secondary oxidative products, respectively (Malheiro *et al.* 2009). K_{232} values of microwave-thawed samples differed significantly from the freshly-prepared and the conventional-thawed ones. Furthermore, k_{270} values were significantly different between samples thawed using conventional oven and freshly-prepared ones. Secondary oxidation products (mainly α-β diketones and α-unsaturated ketones) are formed during CO thawing due to heat.

CSLM images from freshly made sauces (Figure 1A) showed the starch granules immersed in a protein matrix; these starch granules had partially resisted the heat during the elaboration of the sauce. The starch granules in microwave-thawed samples

Table 1. Means of the protein and lipid fraction parameters analysed in freshly-prepared, microwave-thawed and conventional-thawed samples

Sample	Crude protein (g/100 g)	Soluble protein (g/100 g)	Acidity index[1]	K_{232}	K_{270}
Fresh	3.35 (0.18)[a]	0.44 (0.09)[a]	0.92 (0.04)[a]	5.67 (0.64)[a]	1.21 (0.58)[a]
Microwave-thawed	3.75 (0.07)[b]	0.50 (0.05)[a]	0.89 (0.03)[a]	4.80 (.0.20)[b]	1.61 (0.10)[ab]
Conventional-thawed	3.46 (0.05)[a]	0.50 (0.15)[a]	0.91 (0.07)[a]	5.71 (0.28)[a]	1.88 (0.11)[b]

*Values in parenthesis denote standard deviation among measurements; [abc]different letters in the same column indicate significant differences ($P < 0.05$) according to the LSD multiple range test; [1]expressed as percent of oleic acid

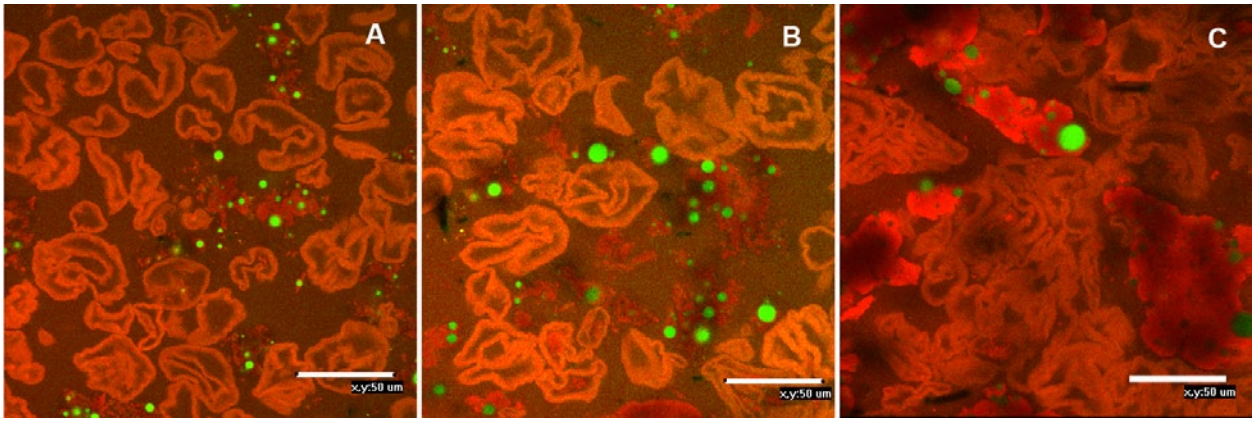

Figure 1. CSLM images of sauces. A: freshly prepared sauce. B: microwave-thawed sauce. C: conventional-thawed sauce. SG starch granules in red, fat globules in green. Magnification 60×

(Figure 1B) showed a slight swelling without evident leaching of the starch components. The starch granules in samples thawed by conventional oven (Figure 1C) were observed gelatinised with leaching of the starch components out of the granule. This difference in the gelatinisation degree must be due to the different thawing times, longer in CO than MO. The fat globules were stabilised by the protein matrix and it can be noticed that the globule size increased when samples were thawed, due to the coalescence produced by heating.

Acknowledgements: The authors are grateful for the economic support (Project AGL2006-11653-C02) received from the Ministerio de Ciencia e Innovación (Spain).

References

Albi T., Lanzón A., Guinda A., Pérez-Camino M.C., León M. (1997): Microwave and conventional heating effects on some physical and chemical parameters of edible fats. Journal of Agricultural and Food Chemistry, **45**: 3000–3003.

AOAC. (1998): Official Methods of Analysis. 16th Ed. Association of Official Analytical Chemist, Washington.

Arocas A., Sanz T., Fiszman S. (2009). Influence of corn starch type in the rheological properties of a white sauce after heating and freezing. Food Hydrocolloids, **23**: 901–909.

Bilbao-Sáinz C., Butler M., Weaver T., Bent J. (2007): Wheat starch gelatinisation under microwave irradiation and conduction heating. Carbohydrate Polymers, **69**: 224–232.

Hassanein M.M., El-Shami S.M., El-Mallah M.H. (2003): Changes occurring in vegetable oils composition due to microwave heating. Grasas y aceites, **54**: 343–349.

Kuchroo C.N., Fox P.F. (1982): Fractionation of the water-soluble-nitrogen from Cheddar cheese: chemical methods. Milchwissenschaft, **37**: 651–653.

Malheiro R., Oliveira I., Vilas-Boas M., Falcão S., Bento A., Pereira J.A. (2009): Effect of microwave heating with different exposure times on physical and chemical parameters of olive oil. Food and Chemical Toxicology, **47**: 92–97.

Meda V., Orsat V., Raghavan G.S.V. (2005): Microwave heating and dielectric properties of foods. In: Schuder H., Regier M. (eds): The Microwave Processing of Foods. CRC Press, Woodhead Publishing, Ltd., Cambridge: 61–75.

Palav T., Seetharaman K. (2006): Mechanism of starch gelatinization and polymer leaching during microwave heating. Carbohydrate Polymers, **65**: 364–370.

UNE (1973): Una Norma Española. Materias Grasas. No. 55-047-73.

Yoshida H., Hirakawa Y., Tomiyama Y., Mizushina Y. (2003): Effects of microwave treatment on the oxidative stability of peanut (*Arachis hypogaea*) oils and the molecular species of their triacylglycerols. European Journals of Lipid Science and Technology, **105**: 351–358.