

## Improving Microwave Heating using Polysaccharides as Thickeners

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**Abstract:** The aim of this work was to improve microwave heating in white sauces using different polysaccharides in their formulation;  $\iota$ -,  $\lambda$ - and  $\kappa$ -carrageenan and native and modified starches were used as thickeners. Five model systems were prepared, each one with a different polysaccharide, salt, and water. Dielectric loss factor ( $\epsilon''$ ) was measured and penetration depth of the electric field was calculated at 20 and 40°C at 2450 GHz. The results showed that  $\epsilon''$  increased significantly ( $P < 0.05$ ) when temperature rose in all the model systems. Moreover,  $\epsilon''$  decreased significantly ( $P < 0.05$ ) when the polysaccharide concentration rose in the systems elaborated with starch (both native and modified). The penetration depth increased significantly at 40°C when native starch concentration rose. Not significant differences due to the thickener concentration were found in the depth penetration values in the other model systems, both at 20 and 40°C.

**Keywords:** polysaccharides; salt; starch; carrageenan; sauces; microwaves; microstructure; dielectric properties

### INTRODUCTION

Microwave ovens (MO) have become an important electrical appliance for consumers to heat foodstuff quickly. Dielectric properties (dielectric constant and loss factor) determine the interaction of electromagnetic energy with the materials in a macroscopic way (METAXAS & MEREDITH 1983). The loss factor ( $\epsilon''$ ) is a measure of the ability of a material to dissipate electrical energy into heat. Penetration depth ( $d$ ) shows how far a wave will penetrate before it reduces to 1/e of its intensity (NDIFE *et al.* 1998).

Polysaccharides are widely used in sauces as thickeners. They are characterised by their capacity to fix water molecules and can affect the dielectric properties of food by changing its hydration and viscosity properties (MILLER *et al.* 1991). Information about dielectric properties of systems with hydrocolloids is scarce. The aim of this study is to

analyse the loss factor and penetration depth of model systems elaborated with different polysaccharides. This will help to optimise the formulation of sauces for microwave heating.

### MATERIALS AND METHODS

**Materials.** Native corn starch (C Gel 03401, Cargill, Inc., USA), modified waxy corn starch (hydroxypropyl distarch phosphate, Polar Tex 06748, Cargill, Inc., USA),  $\iota$ -carrageenan (Secovis IS, Hispanagar, Burgos, Spain),  $\lambda$ -carrageenan (Secolacta BR, Hispanagar, Burgos, Spain),  $\kappa$ -carrageenan (Satiagel RPI 740, Degussa, Essen, Germany) and sodium chloride (Panreac Química SAU, Barcelona, Spain).

**Experimental design and sample preparation.** Five different model systems elaborated with salt and polysaccharide were prepared: native starch

Table 1. Composition of the model systems (in g)

Sample	Model system									
	NSS		MSS		ιCS		λCS		κCS	
	salt	P	salt	P	salt	P	salt	P	salt	P
1–8	4	3.5	4	3.5	4	0.55	4	1.2	4	0.55
9	7	3.5	7	3.5	7	0.55	7	1.2	7	0.55
10	1	3.5	1	3.5	1	0.55	1	1.2	1	0.55
11	1.9	1.7	1.9	1.7	1.9	0.4	1.9	0.9	1.9	0.4
12	6.1	1.7	6.1	1.7	6.1	0.4	6.1	0.9	6.1	0.4
13	4	6	4	6	4	0.8	4	1.6	4	0.8
14	6.1	5.3	6.1	5.3	6.1	0.7	6.1	1.5	6.1	0.7
15	4	1	4	1	4	0.3	4	0.8	4	0.3
16	1.9	5.3	1.9	5.3	1.9	0.7	1.9	1.5	1.9	0.7

P – polysaccharide; NSS – native starch system; MSS – modified starch system; ιCS – ι-carrageenan system; λCS – λ-carrageenan system; κCS – κ-carrageenan system

system (NSS), modified starch system (MSS), ι-carrageenan system (ιCS), λ-carrageenan system (λCS) and κ-carrageenan system (κCS). A surface response methodology was used to determine the amount of salt and polysaccharide in each sample. A central composite rotatable design with two factors (salt and polysaccharides) was used. The amount of the ingredients for each system is showed in Table 1. Samples were prepared by dispersing the ingredients in 100 g of water into a food processor (Thermomix TM 31, Vorwerk, Wuppertal, Germany), heating up to 90°C at 2000 rpm, and keeping at 90°C at the same agitation speed for 6 min. The samples were stored for 24 h at 4°C before being analysed.

**Dielectric properties.** The dielectric constant ( $\epsilon'$ ) and the loss factor ( $\epsilon''$ ) were determined at 2.45 GHz using an open-ended coaxial probe connected to a vector network analyser (Hewlett-Packard 85070M, Hewlett Packard Company, Palo Alto, USA). Each measurement was carried out in triplicate. The penetration depth ( $d$ ) was determined according to Equation 1 (PIYASENA *et al.* 2003):

$$d = \frac{\lambda_0}{2\pi\sqrt{2\epsilon'}} \left[ \sqrt{1 + \left( \frac{\epsilon''}{\epsilon'} \right)^2} - 1 \right]^{-1/2}$$

where:

$\lambda_0$  – wavelength in a vacuum at 2.45 GHz

$\epsilon'$  – dielectric constant

$\epsilon''$  – loss factor

**Statistical analysis.** The statistical analysis was carried out by ANOVA. 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

The contours of response surface corresponding to the loss factor ( $\epsilon''$ ) values at 20 and 40°C for the different systems are shown in Figure 1. The loss factor was significant and positively influenced by the quantity of salt in all the model systems. Regarding the influence of temperature,  $\epsilon''$  values at 40°C were significantly higher than those of 20°C for all model systems. This behaviour was also observed in different heated wheat starch solutions (UMBACH *et al.* 1992) and corn starch solutions (PIYASENA *et al.* 2003); however, the opposite behaviour was found in other type of starches (RYYNÄNEN *et al.* 1996; NDIFE *et al.* 1998). The effect of the polysaccharide level differs depending on the model system. The increase of the quantity of starch used was a significantly negative factor for  $\epsilon''$  in the NSS and MSS. This was already observed by RYYNÄNEN *et al.* (1996) and NDIFE *et al.* (1998). MOTWANI *et al.* (2007) attributed this to the fact that an increase in the amount of starch in the system produces a high

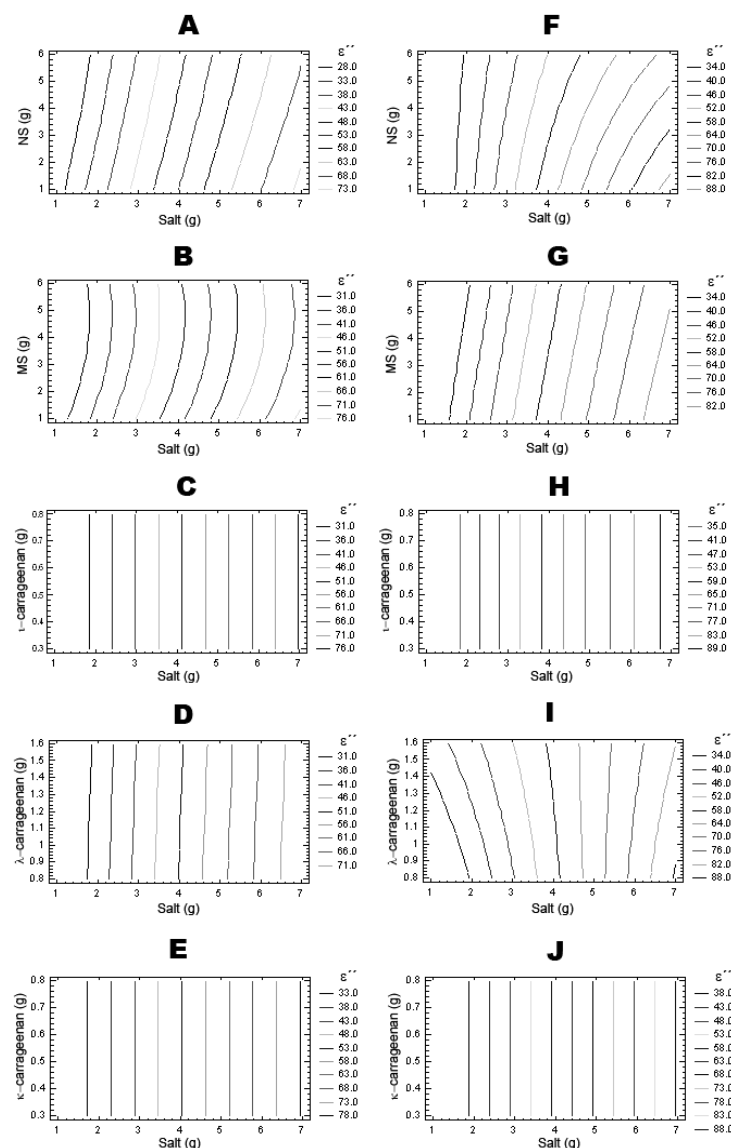


Figure 1. Contours of response surface of dielectric loss factor ( $\epsilon''$ )

A, F – native starch system; B, G – modified starch system; C, H –  $\iota$ -carrageenan system; D, I –  $\lambda$ -carrageenan system; E, J –  $\kappa$ -carrageenan system; NS – native starch; MS – modified starch;  $\iota$ -c –  $\iota$ -carrageenan;  $\lambda$ -c –  $\lambda$ -carrageenan;  $\kappa$ -c –  $\kappa$ -carrageenan. Measurements were carried out at 20°C (A–E) and at 40°C (F–J)

water retention in the molecular chains of starch polymers, which modifies free water affecting the dielectric properties of the system. In S $\iota$ C and S $\kappa$ C the effect of the thickener was not significant whilst in S $\lambda$ C this effect was positively significant at 20°C. Significant interactions between thickener and salt were found at 40°C in S $\lambda$ C.

Penetration depth ( $d$ ) was significantly and negatively affected by the quantity of salt in the system. This observation is not surprising since the penetration depth is inversely related to the loss factor, which increases as the quantity of salt does. Regarding the effect of polysaccharide on penetration depth, only native starch at 40°C made this parameter increase significantly. The values of  $d$  were significantly lower when the temperature increased for all model systems.

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## Improving the Quality of Roasted Hazelnuts During their Shelf-life using Film Coating Starch-Based

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**Abstract:** The “film coating” is a process of depositing a thin layer edible transparent film of material onto a food, in order to provide a functional protective barrier covering its outer surface. The protective function of edible films and coating is to prevent the transfer of moisture, oxygen, flavour, and/or lipid content, between food and the surrounding medium and/or between different compartments in a heterogeneous food. Water-based coating suspensions are desirable to avoid the drawbacks of organic solvent-based coating suspensions. Starch can be used in coating technology; to overcome brittleness inherent of starch films, the incorporation of a plasticiser (reducing intermolecular forces and increasing the mobility of polymer chains, decreasing the glass transition temperature of these materials and improving their flexibility), is required. They must be compatible with the film-forming polymers; hydrophilic compounds, such as polyols are commonly used in starch films (GARCIA *et al.* 2000; JAGANNATH *et al.* 2005). Hazelnut seeds (*Corylus avellana* L.) are largely used in confectionary, chocolate and creams production. The whole roasted hazelnuts are susceptible of oxidation during their shelf-life, because the high content in mono- and polyunsaturated fatty acids. Aim of our work was (1) the elaboration of a coating film (High Amylose Whey Edible Films, HAWEF, under Patenting) able to protect from oxidation roasted hazelnuts in a model system, and (2). the study of peroxidation evolution in coated roasted hazelnuts in plain chocolate tablets. Two plasticisers (sorbitol and glycerol) at two different concentrations were used in film type A (with high % of plasticiser), and type B (with low % of plasticiser), respectively. The protective effect *vs.* the oxidation was evaluated during the storage after 0, 30, 60, 90, and 180 days from coating (peroxide and acidity values). The best compromise in terms of appearance, transparency, detachment of the film after handling and protection to oxidation was identified in the high-amylose edible film with glycerol (type B). We highlight a significant reduction of peroxidation (10–25%) in coated hazelnuts. No changes in aroma were identified in coated samples. Finally, we confirmed the protection of this film *vs.* the oxidation and the souring of the hazelnuts used to prepare plain chocolate with whole hazelnuts. In conclusion, we suggest the use of this edible film for the coating of roasted hazelnut in order to improve their quality during their shelf life.

**Keywords:** hazelnut; roasting; film coating; oxidative spoilage; starch

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