

## SUMMARY

FAT AND SUGAR REPLACEMENT IN SPANISH MUFFINS. EFFECT IN RHEOLOGICAL, THERMAL, TEXTURAL AND SENSORY PROPERTIES.

This thesis is focused on the study of the rheological, thermal, textural and sensory properties of muffins in which fat or sugar were partially or completely replaced.

Muffin batters are an emulsion of oil in water consisting of base grease which incorporates flour and sugar as the main ingredients and, as optional, egg, milk and other components. The final product is characterized by a porous structure and high volume, which gives a spongy texture. The sugar, fat and flour are more functional ingredients in bakery products, making it very difficult to find a replacement capable of performing their same functions.

The rheological characteristics of the batter were determined by studying the pseudoplasticity (rotational tests) and viscoelasticity (oscillatory tests). The viscosity of the batter is an important property in aerated baked goods, because depending on this, an optimal level of air incorporation during mixing can be achieved. The viscosity values obtained as a function of shear rate indicated that the batters studied were within the pseudoplastic area. By replacing fat with cocoa fiber consistency values were higher than those obtained for the control sample. An excessive increase of the consistency could cause problems in handling the batter during the mold filling (dosing) and cleaning problems of the machine. By contrast, in the sugar replacement with polydextrose and sucralose consistency values were lower. The specific gravity measurement provides information about the amount of air incorporated during kneading, and it has been shown that both sugar substitutes improve this incorporation. Furthermore, in the case of replacement of the fat substitutes used an incorporation of air was also observed.

The structural changes that occur during baking in batter are determining factors in the formation and evolution of the bubbles and the

structure and texture of the final product. Usually, the batters showed a decrease in the viscoelastic modules studied during the first heating step, which is associated only to the effect of temperature increment. From 45 °C, this reduction is associated with the formation of CO<sub>2</sub> and its diffusion and expansion into the air cells. From a certain temperature is a turning point in the curve, which is related to the gelatinization of the starch and protein coagulation, that is, the transition from matrix slurry to solid matrix. The presence of sugar, and most of the sugar substitutes used, showed a delay in the temperature at which the inflection of heating curve occurs favouring the expansion of the CO<sub>2</sub> and water vapour. In the case of fat replacement could not determine the temperature at which there was the inflection point of the curve, although a slight increment was observed in the viscoelastic modulus values.

For a better understanding about how they affect fat substitutes or sugar in the process of gelatinization of starch, a study of the batter thermal properties was carried out by differential scanning calorimeter, being observed in all cases a peak around 100 °C, which correspond to the starch gelatinization process.

To carry out the study of the textural parameters texture profile as well as penetration testing and tackiness are analyzed in the final product. The hardness and elasticity parameters are the best associated with product freshness and the parameters were more affected by the replacement of both fat and sugar. The use of erythritol as a sugar substitute considerably increased hardness to the product while the remaining values were obtained sweeteners similar to the control formulation. Furthermore, when the fat was replaced by cocoa fibre as Nutriose®, the elasticity and hardness values decreased.

In addition to the texture, there are also other characteristics related to the crumb structure may influence the acceptability of the product such as the shape, height, volume, counting and distribution of air cells. All these parameters were modified negatively greater or lesser extent when the sugar or

fat were replaced, so that in these cases the use of xanthan gum and double concentration of bulking agent would be advisable.

Sensory characteristics of the Spanish muffins were evaluated generating descriptors that best define the sensory quality of the product using a trained panel and also studying the acceptance of new products using a consumer panel. In samples where cocoa fibre was used as a fat substitute the trained panel identified the following descriptors: height, colour of chocolate, fluffiness, elasticity, adhesion to the mould, cohesion, difficulty in chewing and swallowing, bitter taste, sweet chocolate flavour. The control formulation is defined as the formulation with increased adhesion to the mould height, sponginess, elasticity, chocolate flavour and colour. By contrast, formulations with higher percentage of fat by replacing cocoa fibre as defined more cohesive, with worse chewiness, and higher odour and bitter taste. Consumers evaluated the acceptability of all samples prepared with reduced fat and sugar evaluating the appearance, colour, texture, flavour, sweetness and overall acceptance. In all cases studied, the control formulation (with all the fat and sugar) was well appreciated by consumers in all attributes. When sugar was replaced by sweeteners no differences were found in the acceptance of the formulations with 100% replacement of sugar or sorbitol or maltitol in the case of replacement of 50% of sucralose sugar and polydextrose. As happened with the replacement of sugar, when 50% of the fat was replaced by Nutriose® no differences in acceptance for the control formulation.

