Kinetics of nitrite evaluated in a meat product

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The evaluation of the efficiency with which the reactions involving nitrite proceed in mortadella and of the effect exercised on their kinetics by some variables (ingoing amount of sodium nitrite and temperature) is the purpose of this work. Kinetics parameters were calculated at each level of nitrite added (40, 70, 100 and 150 mg/kg) and at five temperature (55°, 60°, 65°, 70° and 72 °C). While the colour formation reaction is favoured by low activation energy, it becomes crucial to enable nitrite to proceed according to direct reduction thus preventing an increase in nitrate concentration as well as an excess of nitric oxide in the product. Kinetics data suggest that this scope is performed when the product achieves the temperature of 65 °C as fast as possible with an ingoing amount of sodium nitrite of 70 mg/kg.

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1. Introduction

Sodium nitrite is an additive used widely in meat products. It is involved in a number of functions: 1) it controls the development of some pathogenic species (Duffy, Vanderlinde, & Grau, 1994; Glass, McDonnell, Rassel, & Zierke, 2007; Yetim, Kayacier, Kesmen, & Sagdic, 2006); 2) it develops the typical pink colour of cooked ham (Cornforth & Jayasingh, 2004; Lawrie, 1998); 3) it contributes to flavour formation (Guillard, Goubet, Salles, Le Quéré, & Vendeuvre, 1998); and 4) it exerts an antioxidant action against fats (Gatellier, Lessire, Hermier, Maaroufi, & Renerre, 2003; Han & Yamauchi, 2000). On the other hand, nitrite also plays a substantial role in formation of the carcinogenic N-nitrosamine in meat, especially under the process conditions applied in the meat processing industry (Juncher et al., 2000; Lijinsky, 1999; Ward et al., 2007).

Numerous studies have been carried out to replace nitrite in meat products (Dineen et al., 2000; Kawahara, Nakamura, Sakagami, & Suzuki, 2006; Pegg & Shahidi, 1997; Shahidi & Pegg, 1995; Sorheim et al., 2006; Viuda-Martos et al., 2009), but so far none of the alternatives found are as effective in colour formation or bacteriostatic action on pathogenic species such as listeria and clostridium (Lucke, 2008). Reducing the use of nitrites has also been the subject of studies (Hammer, 1998) by European legislators (Dir 2006/52/CE; Dec UE 2010/561).

Mortadella is a product made with finely ground pork meat (shoulders and trimmings from other cuts) combined with diced pork fat taken from the throat or belly, which is stuffed into natural casing or, more frequently, synthetic casing. This product requires a long cooking time in a dry air oven, during which numerous chemical reactions can take place between the various meat components and additives (Cornforth & Jayasingh, 2004; Fox, 1966; Sebranek & Fox, 1985). The reactions involving nitrite can be classified, for the sake of simplicity, as concurrent reactions that consume it (dismutation and reduction), and produce, among other compounds, nitric oxide (NO). Nitric oxide, in turn, also reacts in various ways, concurrent with one another. At the pH of meat, generally 5.65 up to 5.85, nitrite is mostly present in the dissociated form, nevertheless, the reactivity of undissociated forms leads to the formation of several intermediates, which are unstable and therefore difficult to determine, especially in a real system subjected to thermal treatment. Nitrite consumption can be due to the action of reducing substances endogenous to the meat, e.g. sulphur-containing amino acids (cysteine), or added ones such as ascorbate. In addition, a nitrite dismutation reaction also results in nitrate formation. The consumption of NO occurs by a reaction with both the denatured pigment of meat and with some substrates present in the mixture, such as the biochemical cellular systems of microorganisms, which prevents their growth and preserves the meat product from a microbiological point of view (Reddy, Lancaster, & Cornforth, 1983). Therefore, the amount of NO developed is an important parameter when evaluating the effect of added nitrite on the microbiological shelf-life of the product, with the aim of minimizing excess. In addition to reduce the nitrite addition, it is also important to keep the residual of nitrate and nitrite residues as low as possible. So far, the kinetics of nitrite has been studied only on model systems (Fox et al., 1994; Geielsley et al., 1998).

The purpose of this work was to study the kinetics of nitrite decreasing by following the evolution of analytically measurable chemical species (NO, NO2, total pigments, and nitric oxide pigments) and calculate the content of NO through stoichiometry of the reactions considered during the production of mortadella in an industrial plant. In addition, we evaluated the efficiency with which, in a real system, important