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Study of metal release from stainless steels in simulated food contact by means of total reflection X-ray fluorescence

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ABSTRACT

This study shows a reliable procedure to prescribe the preferential use of a material for food contact. Release tests with optimized parameters were performed on six different stainless steel accepted for the use in food contact: AISI 420, AISI 430, AISI 202, AISI 303, AISI 304, and AISI 316. Total reflection X-ray fluorescence spectroscopy was used to measure the concentration of Cr, Mn and Ni in contact solutions from release tests. Results show that AISI 202 and 430 release the lowest amount of Mn, Cr and Ni. While, AISI 420 is the worst material, exceeding the limit set in the Italian regulation for all the three metals of interest. One sample was selected to test the reproducibility of TXRF measurements performed in three different laboratories around the world. Results show that quantitative analyses by means of TXRF satisfy the requirements of this field of application.

1. Introduction

The release of metals from materials used in food contact is an interesting field of application for elemental chemical analysis of water based solutions. Metals and alloy based materials are used for food contact mainly in processing equipment, containers and household utensils. Very often they are covered with a surface coating, to reduce metal transfer in foodstuffs. Indeed, when they are not covered, leaching of metal ions into food may occur, with possible negative effects on human health if the total content exceeds the sanitary recommended exposure limits (CoE, 2002).

Stainless steels are widely used in food contact applications, such as cooking utensils and in cutlery, due to their high corrosion resistance and superior mechanical properties. Steel is an alloy of iron and carbon (less than 2% carbon), which may contain other elements such as Mn, Si, S, Ni, Cr, and Mo to modify or improve its properties. The most frequently used steel grades for food applications are the austenitic ones, such as AISI 304 and AISI 316, both containing 16–20 wt% Cr and 8–14 wt% Ni. Alloying with nickel enhances the corrosion resistance leading to slower kinetics of metal release (Herting et al., 2008a; Wallinder et al., 2006).

Several papers about the release of alloy constituents into different food and food simulants have been published (Accominotti et al., 1998; Chiavari et al., 2014; Herting et al., 2009, 2008a; Jellesen et al., 2006; Kamerud et al., 2013; Kumar et al., 1994).

The Italian Ministerial Decree of March the 21st 1973 (Text, 1973) is one of the most detailed regulation text on global migration. According to this text the most relevant constituents of stainless steel, whose migration in food contact must be considered, were Cr and Ni. A more recent update of the Italian regulation have included Mn to the list of elements to verify its specific migration (Health, 2013).

Chromium is an essential element required for sugar and fat metabolism (Anderson, 1997). The estimated safe daily dietary intake of Cr(III) is 50–200 μg for humans, and there are no documented toxic effects in nutritional studies at levels up to 1 mg per day (Anderson, 1997). On the contrary, Cr(VI) is carcinogenic and the World Health Organization (WHO) has set its maximum value at 0.05 mg/L in drinking water (WHO, 2008).

Nickel is a fundamental component of stainless steels whose

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