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Flame photometric determination of salinity in processed foods

Min-Jane Chen [a,*], Ya-Ting Hsieh [b], Yih-Ming Weng [b], Robin Y.-Y. Chiou [c]

[a] *Department of Applied Chemistry, National Chiayi University, 300 University Road, Chiayi 60083, Taiwan, ROC*
[b] *Department of Food Science, National Chiayi University, 300 University Road, Chiayi 60083, Taiwan, ROC*
[c] *Graduate Institute of Biotechnology, National Chiayi University, 300 University Road, Chiayi 60083, Taiwan, ROC*

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Abstract

The sodium contents determined by flame photometry were used to estimate the salinities of processed foods. The interference effects of potassium and calcium ions on the determination of sodium ion were studied. The threshold interfering patterns of potassium ion and calcium ion for the determination of sodium ion were observed in the model systems. Both of the ions showed enhancement effects on the signals of sodium determination and the increased signal strength depended on the concentration of the ions added above a threshold level. While low level calcium ion hardly interferes with the measurement of sodium ion, the potassium ion exerts marked interfering effects. The salinities based on the chloride contents from Mohr's titration method were obtained for comparison purpose. The salinities of 48 processed food samples determined by the two methods were positively correlated with $r^2 = 0.9995$ and did not show significant difference in the paired t tests ($P = 0.2504$). Overall, the flame photometric determination of sodium ion provides a rapid, less tedious and more accurate alternative for the quantification of salinity in processed foods.

Keywords: Salinity; Sodium ion; Flame photometry; Interference effects

1. Introduction

Sodium chloride is the most important salt in human diet. In current theory, the dietary intake of sodium chloride is closely related to the development of hypertension and other cardiovascular diseases (Robinson, Lawler, Chenoweth, & Garwick, 1989). It has also been found that the sodium ion rather than chloride ion is responsible for such adverse effects (Herlitz, Dahlof, Jonsson, & Friberg, 1998). For the purpose of promoting flavor and increasing shelf life, sodium chloride is an essential ingredient in all processed foods. Thus, the salt contents present in foods are of great concerns for food processing and health care.

Mohr's titration method is commonly accepted as one of the methods for the determination of salinity in foods. In Mohr's method, the salinity of food is calculated based on the concentration of chloride ion titrated with silver nitrate solution. However, disadvantages of using Mohr's method include the de-coloration pretreatment required for foods with deep color, the adjustment to nearly neutral condition before titration (Skoog, West, Holler, & Crouch, 2000), and possible side reactions of silver ion with other anions such as carbonate or phosphate. Thus, the determination of salinity based on the direct determination of sodium ion might provide possible alternatives to overcome these disadvantages.

Atomic absorption spectrophotometry (Orzáez Villanneva, Díaz Marquina, Arribas de Diego, & Blázquez Abellán, 2000; Vaessen & van de Kamp, 1989), inductively coupled plasma-atomic emission spectrometry (ICP-AES) (Fabec & Ruschak, 1985; Fingerová & Koplík, 1999), inductively coupled plasma-mass

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[*] Corresponding author. Tel.: +886 5 2717611; fax: +886 5 2717901.
E-mail address: librac@mail.ncyu.edu.tw (M.-J. Chen).

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spectrometry (ICP-MS) (Fernández-Turiel et al., 2000; Fingerová & Koplík, 1999), ion selective electrode method (Balulescu, 1985; Fulton, Meloan, Wichman, & Fry, 1984) and flame photometry (Folarin, Bamiro, & Esuoso, 2001; Leenheer & Jans, 1986) are methods for direct detection of sodium ion concentration. Among them, flame photometry is a simple and relatively inexpensive method. Flame photometric technique was introduced around 1950s and many efforts on improving instrumentations or procedures were made to reduce interference and increase sensitivity (Dubbs, 1952; Porter & Wyld, 1955; Schrenk & Gendening, 1955; Spector, 1955). Applications of this method in determination of sodium ion concentrations in a wide variety of samples have been reported (Biffen, 1950; Havre, 1961; Inman, Rogers, & Fournier, 1951; Kingsley & Schaffert, 1953). Although the interference effects depend on the types of the samples (Havre, 1961), the method has been used for quantification of sodium ion in many food samples (Balulescu, 1985; Folarin et al., 2001; Fulton et al., 1984) without taking the interference of other food components into consideration.

For the sake of convenience or dietary habit, people around the world consume large quantity of processed foods in their daily life. The purpose of this investigation is to evaluate the feasibility of flame photometry in the determination of food salinity and the interference effects of potassium and calcium on the determination of salinity in processed foods.

2. Experimental section

2.1. Flame photometry

Flame photometry was conducted according to Helrich (1990). A simple flame photometer (Model 410, Corning, Halstead, UK) with filters for lithium, sodium, and potassium was used. Liquefied petroleum gas (China Petroleum Company, Taipei, Taiwan) and air were supplied as the source of flame. The flow rate of fuel was adjusted to get a maximum sensitivity. Standard curve with sodium concentration between 5 and 30 ppm was established daily and the signal of 30 ppm standard was checked occasionally during the analysis. The sodium content in appropriately diluted food sample was determined against the standard curve and the salinity (content of sodium chloride on weight basis) of the original food sample was calculated. Means with standard deviations of triplicate determinations were reported.

2.2. Mohr's titration

Mohr's titration was carried out according to Skoog et al. (2000) and James (1995). Silver nitrate, sodium chloride, potassium chromate and sodium bicarbonate were purchased from Hayashi Chemical Ltd. (Osaka, Japan). Silver nitrate solution (0.1 M) was standardized with pure sodium chloride. Sodium bicarbonate powder was used to adjust pH of testing solution to nearly neutral if necessary. Potassium chromate (5%, 1 mL) was used as indicator during silver nitrate titration and the appearance of brick red precipitates was taken as the end point. Double distilled water served as the blanks was also included. The salinity of the food sample was calculated according to the amount of titrated chloride ion. Means with standard deviations of triplicate determinations were reported.

2.3. Sample preparation

Forty-eight food samples (Table 1) were chosen to analyze the salt content in this study. The selection criteria were based on the consumer preference, the representative for plant-origin and animal-origin foods, and different salt contents. The commercial package sizes for these food samples were 0.25–1.0 kg. All samples were purchased from local supermarkets and stored in a refrigerator (4 °C) until used. In the case when packing liquid and solid matter were packed together, the whole content was homogenized (Waring blender; Dynamics Co., New Hartford, CT, USA). A portion of slurry (10 g) was sampled and mixed with double distilled water (40 mL) and centrifuged (15,000*g*, 4 °C, 10 min; Centrifuge, Hitachi, Japan); and the supernatant was diluted and used in the analysis. For paste type foods, portion of sample (10 g) and double distilled water (40 mL) were homogenized, centrifuged and diluted as mentioned above. For Mohr's titration, deep-colored liquid samples (e.g. soy sauce) were de-colored by stirring with activated carbon (1 g activated carbon and 40 mL double distilled water per 10 g soy sauce) under boiling for 10 min, then filtered to remove active carbon and diluted. All the samples for metal ion determination were stored in polyethylene bottles that were cleaned, bathed in 5% HNO_3 overnight, and rinsed twice with double distilled water.

2.4. The influence of potassium and calcium ions on flame photometric determination

Potassium ion (0–5 ppm) and calcium ion (0–100 ppm) were separately added into standard sodium ion solutions (1, 10, and 20 ppm) to evaluate the interference effects. The relative error of the sodium contents due to the presence of potassium and calcium ions was determined. To investigate the interference effects on food samples, a predetermined amount of potassium or calcium ion was added into diluted food sample prior to flame photometric analysis.