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Analytical Methods

Potentiometric sensor for sorbic acid determination in food products

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ABSTRACT

The construction, evaluation and application of a new potentiometric sensor, namely, Pt|Hg|$Hg_2(SOB)_2$|Graphite, where SOB stands for sorbate ion, are described. This electrode has a wide linear dynamic range between 5.0×10^{-7} and 1.0×10^{-2} mol L^{-1} with a near-Nernstian slope of (−58.6 ± 1.3) mV decade^{-1} and a detection limit of 4.3×10^{-7} mol L^{-1}. The potentiometric response is independent of the pH of the solution in the pH range 6.0–9.0. The electrode is easily constructed at a relatively low-cost with fast response time (within 15–30 s) and can be used for a period of 4 months without significant change in its performance characteristics. The proposed sensor displayed good selectivities over a variety of other anions (carboxylates and inorganic anions). The potentiometric sensor was successfully applied to the determination of sorbic acid in real food samples, that is, soft drinks, skim yogurts, jams and sauces.

1. Introduction

Food preservatives are added to stop or delay nutritional losses due to microbiological, enzymatic or chemical changes of foods during its shelf life. They also prevent consumer hazards due to the presence of microbial toxins or pathogenic microorganisms and economic losses due to spoilage (Davidson, 1997).

Benzoic and sorbic acids, and their respective sodium, potassium and calcium salts are the most commonly used preservatives in foodstuffs. They are generally used to inhibit yeast and mould growth, being also effective against a wide range of bacteria. These compounds are most active in foods of low pH value and essentially ineffective in foods at neutral pH values (Sofos, 1995).

The development of allergic reactions to benzoates in humans, such as urticaria, non-immunological contact urticaria and asthma, has been reported in some studies (Hannuksela & Haahtela, 1987). Other studies showed that sorbic acid has low toxicity, explained by the fact that it is rapidly metabolised by pathways similar to those of other fatty acids. In humans a few cases of idiosyncratic intolerance to sorbic acid have been reported (non-immunological contact urticaria and pseudo-allergy) (Walker, 1990). For the abovementioned reasons, sorbic acid and sorbates salts (specially potassium sorbate) have become the leading preservatives for a wide variety of food products (Lück, 1990; Sofos, 1989).

The acceptable daily intake (ADI) values, determined by the Joint FAO/WHO Expert Committee on Food Additives (JECFA), is 25 mg/kg of body mass for sorbic acid and sorbates salts.

The reference methods (AOAC, 1990) for the determination of sorbic acid in food products recommend tedious methodologies, with extensive extraction procedures, involving large amounts of reagents incurring considerable costs.

Various analytical methods for the determination of sorbic acid in food products have been reported in the literature, such as: polarography (Fung & Luk, 1990), spectrophotometry (Sofos, 1989), gas–liquid chromatography (Coelho & Nelson, 1983; Graveland, 1972; Larson, 1983), high-performance liquid chromatography (Bui & Cooper, 1987; Burini & Damiani, 1991; Ferreira, Mendes, Brito, & Ferreira, 2000; García, Ortiz, Sarabia, Vilches, & Gredilla, 2003; Pylypiw & Grether, 2000; Saad, Bari, Saleh, Ahmad, & Talib, 2005), gas chromatography–mass spectrometry (Kakemoto, 1992); capillary electrophoresis (Pant & Trenerry, 1995; Tang & Wu, 2007) and titrimetry (Lau & Luk, 1987). However, many of these methods are often complicated and time consuming or require expensive equipment. Thus, there is an important demand for simple, low-cost, sensitive and rapid alternative methods for the determination of sorbic acid in food products.

Potentiometric detection based on ion-selective electrodes (ISEs) have proved to be effective for the analysis of pharmaceutical formulations, biological and food samples, because these sensors offers great advantages such as speed and ease of preparation and procedures, relatively short response times, reasonable selectivity, wide linear dynamic range, low-cost and possible interfacing with automated and computerised systems (Lewenstam, Maj-Zurawska, & Hulanicki, 1991).

To the best of our knowledge, there are no previous reports on the use of potentiometric sensors for the determination of sorbic acid in food products.

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The present work describes the development, evaluation and application of a simple, and low-cost potentiometric sorbate ion sensor immobilised in a graphite matrix (Pt|Hg|$Hg_2(SOB)_2$|Graphite, where SOB stands for sorbate ion) for the determination of sorbic acid in real food samples, such as soft drinks, skim yogurts, jams and sauces. The new proposed sensor has the advantages of simplicity, fast response, fair stability and repeatability and very low detection limit.

2. Experimental

2.1. Reagents

High purity deionised water (resistivity 18.2 MΩ cm) obtained by using a Milli-Q Plus system (Millipore Corp., Bedford, MA, USA) was used throughout. All reagents employed were of analytical grade and obtained from E. Merck (Darmstadt, Germany) except sorbic acid and potassium sorbate, which were supplied by Sigma (St. Louis, MO, USA).

The potassium sorbate (KSOB) stock solution (2.0×10^{-1} mol L^{-1}) was prepared in deionised water at constant pH (7.5 ± 0.1). This solution is stable at least 1 month when stored in darkness (under aluminium foil) at 5 °C (Sofos, 1989).

Standardisations of carbonate – free potassium hydroxide, nitric acid and potassium nitrate solutions were performed as described elsewhere (Moraes et al., 1996). Metallic mercury was purified according to a previously reported procedure (Moraes et al., 1996). $Hg_2(SOB)_2$ was prepared by mixing, in aqueous solution, the corresponding nitrate with an excess of KSOB. The resulting precipitate was filtered through a sintered glass funnel, washed with deionised water until nitrate free, and then dried in a desiccator, over calcium chloride under reduced pressure, at room temperature, to constant mass.

2.2. Electrode preparation and conditioning

The $Hg_2(SOB)_2$ indicator electrode was prepared as follows: $Hg_2(SOB)_2$ (1.9 g) and metallic mercury (*ca.* 0.3 g) were mixed in an agate mortar and the material was crushed until a homogeneous solid was obtained. Pure powdered graphite (1.3 g) was then added and the crushing process was continued until perfect homogenisation was attained. Part of the resulting solid was transferred to a press mould, being compressed at 9 tons for about 6 min. The black pellet (1.6 mm thick, 12 mm o.d., and 0.8 g mass) was fixed at one end of a glass tube (12 mm o.d., 80 mm long) with a silicone-rubber glue ("Rhodiastic", Rhône-Poulenc, France) and allowed to dry for 48 h. Sufficient metallic mercury (*ca.* 0.6 g) was then introduced into the tube to produce a small pool on the inner pellet surface; electric contact was established through a platinum wire plunged into the mercury pool and a subsequent conductor cable. Similar to the previous mercury(I)-carboxylate electrodes reported by the authors this electrode is sealed (Pezza et al., 2001). This feature, coupled with the small amount of metallic mercury placed inside the electrode (*ca.* 0.6 g), stresses that the considered sensor does not offer significant risk to the operator's health and can thus be recognised as safe.

When not in use, the electrode's pellet was kept immersed in a small volume of a 0.010 mol L^{-1} KSOB solution (freshly prepared, pH = 7.5) whose ionic strength (μ) was adjusted to 0.500 mol L^{-1} with KNO_3.

Before carrying out each experiment, the external surface of the aforementioned pellet was washed with deionised water and dried with absorbent paper.

2.3. Instruments

The electromotive force (emf) values were read to the nearest 0.1 mV with a Metrohm model 692 pH|ion meter (Metrohm Ltd., Herisau, Switzerland).

The reference electrode was a Metrohm Ag|AgCl double junction, model 6.0726.100. The pH of aqueous solutions was adjusted and monitored with the aid of a Metrohm pH electrode, model 6.0234.100. A thermostated titration cell (25.0 ± 0.1 °C) was employed.

For accuracy assessment of the results obtained by the proposed method, the food samples were analyzed using a comparative HPLC method (Pylypiw & Grether, 2000). The HPLC system used consisted of a Shimadzu SPD-10A liquid chromatograph (Shimadzu Seisakusko Kyoto, Japan) equipped with a LC-10AS Shimadzu pump, variable UV–Visible detector (SDR-10A, Shimadzu) set at 255 nm and a Rheodyne 20 μL injector. A stainless steel Supelcosil LC-18 analytical column was used (250 × 4.6 mm i.d., Supelco, Bellefonte, PA, USA) with 5 μm particle size packing material. The mobile phase consisted of a mixture of 90% ammonium acetate buffer with 10% HPLC-grade acetonitrile and was prepared in a manner similar to a previously reported procedure (Pylypiw & Grether, 2000). Before injection, the samples were filtered through a Millex unit (Millex-HV, 0.45 μm, Millipore). Chromatograms were recorded and peak area measured with an integrator (Shimadzu C-R6A Chromatopac recording integrator).

Volume measurements (±0.001 mL) were performed using a Metrohm model 665 automatic burette.

All experiments were performed in a thermostated room, maintained at 25 ± 1 °C.

2.4. Potentiometric cell

The following cell was used

(−)Ag|AgCl	$[KCl]_{(aq)}$ = 0.010 mol L^{-1} $[KNO_3]_{(aq)}$ = 0.490 mol L^{-1}	$[KNO_3]_{(aq)}$ = 0.500 mol L^{-1}	$[KSOB]_{(aq)}$ = x mol L^{-1} $[KNO_3]_{(aq)}$ = $(0.500 - x)$ mol L^{-1}	Graphite|$Hg_2(SOB)_2$|Hg|Pt(+)

where SOB stands for sorbate ion and x was in the range 1.0×10^{-1}–1.0×10^{-7} mol L^{-1}. The ionic strength (μ) of the cell compartments was kept constant at 0.500 mol L^{-1}. The outer compartment of the reference electrode was refilled periodically with fresh KNO_3 solution.

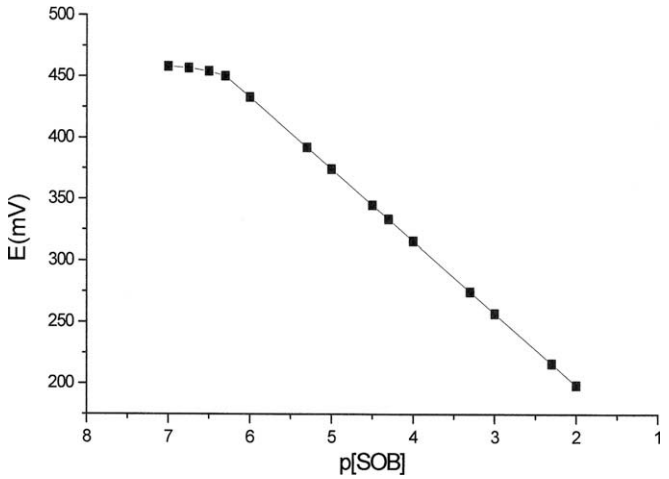

Fig. 1. Calibration graph for the proposed sorbate-sensitive electrode (pH = 7.5 ; μ = 0.500 mol L^{-1} adjusted with KNO_3, T = 25 °C).

The performance of the $Hg_2(SOB)_2$ electrode was assessed by measuring the emf of the aforementioned cell for 1.0×10^{-1}–1.0×10^{-7} mol L^{-1} KSOB solutions. These solutions were freshly prepared by serial dilution of a 2.0×10^{-1} mol L^{-1} stock standard solution with deionised water, at constant pH (7.5 ± 0.1) and μ adjusted to 0.500 mol L^{-1} with KNO_3. The emf readings were obtained for solutions under stirring and recorded when they became stable. A typical calibration plot of the electrode is shown in Fig. 1.

2.5. Determination of sorbic acid in food samples

Food samples, claimed to contain sorbic acid as a preservative at permitted concentrations, and taken into our study included soft drinks, skim yogurts, jams and sauces were purchased from local market and all were tested prior to the listed expiration date. The extraction procedures used to process food samples as soft drinks, skim yogurts, jams and sauces were performed according to a previously reported procedure (Kakemoto, 1992) with a few modifications.

2.5.1. Determination of sorbic acid in soft drinks

The samples of these carbonated soft drinks were degassed for 3 min in an ultrasonic bath before the analysis.

To 10 mL of a certain soft drink sample, 1.0 mL of 0.1 mol L^{-1} HNO_3 and 2 mL of satured potassium perchlorate were added and mixed for 60 s. The sample was then extracted twice with 10 mL of ethyl ether and vortex mixed for 2 min for each extraction. The collected organic phase was then transferred to an appropriate flask and evaporated in a rotary evaporator under reduced pressure to dryness. The resulting residue was dissolved in 10 mL of 0.500 mol L^{-1} KNO_3 (pH = 7.5 ± 0.1) and an aliquot of 8 mL of the solution was employed for analysis with the sorbate-sensitive electrode using the standard additions method (multiple addition method).

2.5.2. Determination of sorbic acid in skim yogurts, jams and sauces

An appropriate amount (typically between 0.5 and 1.0 g) of a certain food sample(skim yogurts, jams or sauces) was weighed, dissolved in 25 mL of deionised water and homogenised with magnetic stirring for 5 min. The suspension was filtered, first through filter paper and then twice through a 0.45-μm Millipore filter, to remove turbidity. To 10 mL of the sample, 1.0 mL of 0.1 mol L^{-1} HNO_3 and 2.0 mL of saturated potassium perchlorate were added and mixed for 60 s.

The sample was then extracted twice with 10 mL of ethyl ether and vortex mixed at least 2 min for each extraction. The collected organic phase was pooled (20 mL), transferred to an appropriate flask and evaporated in a rotary evaporator under reduced pressure to dryness. The resulting residue was dissolved in 10 mL of 0.500 mol L^{-1} KNO_3 (pH = 7.5 ± 0.1) and an aliquot of 8 mL of the solution was employed for analysis with the sorbate-sensitive electrode using the standard additions method (multiple addition method).

Table 1
Potentiometric response characteristics of the sorbate-sensitive sensor[a].

Slope (mV decade^{-1})[b]	(−58.6 ± 1.3)
Intercept, E^0 (mV)[b]	81.3 ± 1.2
Linear range (mol L^{-1})	5.0×10^{-7}–1.0×10^{-2}
Detection limit (mol L^{-1})	4.3×10^{-7}
Response time (s)	15–30
Working pH range	6.0–9.0
Analytical application	Sorbic acid determination in food products

[a] T = 25.0 ± 0.1 °C; pH = 7.5 ± 0.1; μ = 0.500 mol L^{-1} (KNO_3).
[b] Average value ± SD of 34 determinations over a period of 4 months. Number of data points: 20–25. Mean linear correlation coefficient: 0.997 ± 0.005.

3. Results and discussion

3.1. Electrode response

Experiments carried out as described in Section 2.4 led to the following linear relationship between the measured emf (E, in mV) and SOB ion concentration:

$$E = E^0 - S \log [\mathrm{SOB}]$$

where E^0 is the formal cell potential and S represents the Nernst coefficient (59.16 mV/decade, at 25 °C, for monovalent ions). Potentiometric parameters and other features associated with the $Hg_2(SOB)_2$ electrode are given in Table 1. The above calibration equation and the slope value (Table 1) show that the electrode provides a near-Nernstian response to the sorbate ion in the range of 5.0×10^{-7}–1.0×10^{-2} mol L^{-1} (75.1 μg L^{-1}–502 μg L^{-1}). The limit of detection, as determined from the intersection of the two extrapolated segments of the calibration graph (Fig. 1), was 4.3×10^{-7} mol L^{-1} (64.6 μg L^{-1}) (Buck & Lindner, 1994). The sensor response displayed good stability and repeatability over the tests; the last mentioned feature is illustrated by the standard deviation values shown in Table 1.

3.2. Response time and lifetime of the electrode

For analytical applications, the response time and the lifetime of a sensor are of critical importance. According to IUPAC recommendations, the response time may be defined as the time between the addition of analyte to the sample solution and the time when a limiting potential has been reached (Buck & Lindner, 1994).

The response time of the electrode was tested by measuring the time required to achieve a steady state potential (within ±0.2 mV/min), for 1.0×10^{-2}–5.0×10^{-7} mol L^{-1} KSOB solutions at pH 7.5 (Buck & Lindner, 1994). The electrode yielded steady potentials within 15–20 s at high concentrations ($\geqslant 1.0 \times 10^{-3}$ mol L^{-1}) and about 30 s at concentrations near the detection limit. The experimental results show that the lifetime of the electrode was about 4 months, with a total of 460 determinations. During this period, the sensor was in daily use and was stored in 0.010 mol L^{-1} KSOB solution (freshly prepared, pH = 7.5 and μ = 0.500 mol L^{-1} adjusted with KNO_3) when not in use. No significant change in working concentration range, slope and response time was observed during this period.

3.3. pH Effect

The pH dependence of the potentials of the proposed electrode was tested over the pH range 4.0–10.0 for 1.0×10^{-3} and 1.0×10^{-4} mol L^{-1} SOB ion concentrations. The resulting solutions' pH(s) were adjusted with diluted HNO_3 or KOH solutions. As it can be seen in Fig. 2, the potential response remains almost constant over the pH range 6.0–9.0 which can be taken as the working pH range of the electrode.

However, for pH values below 6.0, significant fractions of sorbate ion (pKa = 4.75) (Renner, Baer-Koetzle, & Scherer, 1999) changes to the corresponding protonated form which is not detected by the electrode. For pH > 9.0, the hydroxide ion interferes with the electrode's response. In high pH media, probably OH^- competes with sorbate ion in the electrode process and alters the potentiometric response of the proposed sensor.

3.4. Electrode selectivity

The potentiometric selectivity coefficient, which reflect the relative response of a sensor for the primary ion over other ions, present in solution, is perhaps the most important characteristic of any

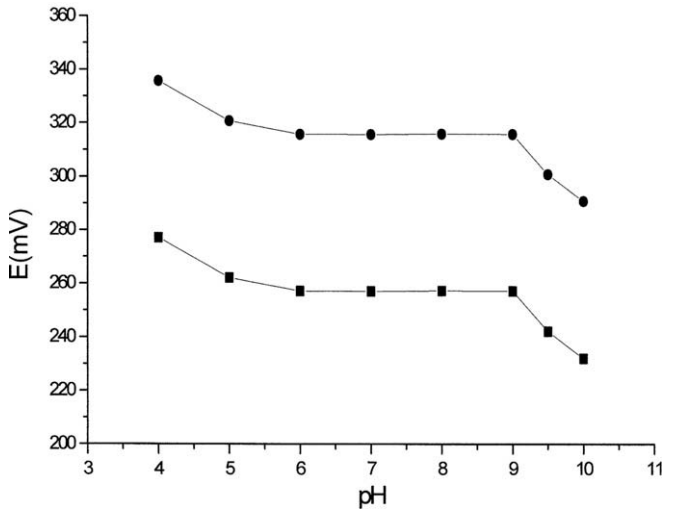

Fig. 2. Effect of pH on the electrode's response at: (■) 1.0×10^{-3} mol L^{-1} SOB, (●) 1.0×10^{-4} mol L^{-1} SOB ; μ = 0.500 mol L^{-1} adjusted with KNO_3 , T = 25 °C.

ion sensitive sensor. The potentiometric selectivity coefficients for the sorbate-sensitive electrode ($K_{SOB,M}$) were determined, for a number of interfering ions, by the matched potential method (MPM) (Gadzekpo & Christian, 1984). In this method, the selectivity coefficient is defined by the ratio of the activity of the primary ion relative to an interfering ion, when they generate identical potentials in the same reference solution. In the MPM method, both monovalent and divalent ions are treated in the same manner and the valence of the ions does not influence the selectivity coefficient. Furthermore, the MPM can be used with no regard to the electrode slopes being Nernstian or even linear (Bakker, Bühlmann, & Pretsch, 1997).

The MPM-selectivity coefficients ($K_{SOB,M}$) were determined under the following conditions: Initial reference solution (pH = 7.5) contains 0.500 mol L^{-1} KNO_3 as a supporting electrolyte and 1.0×10^{-5} mol L^{-1} of the primary ion (sorbate). The selectivity coefficients were calculated from the concentration of the interfering ion (M), which induced the same amount of the potential change (Δemf = 15.0 mV) as that induced by increasing the concentration of primary ion. The resulting values of $K_{SOB,M}$ are presented in Table 2.

The results comprised in the aforementioned Table 2 show that the selectivity of the $Hg_2(SOB)_2$ electrode towards all tested organic acid anions is good. Benzoate also is used as food preservative; citrate and folate are found in many food products. No interference was noted for most of the common components found along with sorbic acid in the selected food samples (soft drinks, skim yogurts, jams and sauces) such as acesulphame K, aspartame, sodium cyclamate, sodium saccharin, sugars, phosphoric acid, citric acid, lactic acid, benzoic acid, arabic gum, pectins, lemon-flavoured, orange juice, strawberry, ammonium sulphate of caramel, Sunset Yellow, Ponceu 4R, sorbitol syrup, vitamin A, vitamin B2, vitamin B12, pantothenic acid, calcium, phosphorous, potassium, tomato pulp, vinegar and sucrose.

Sulphate and borate has a very low selectivity coefficient (Table 2); no interference at all is caused by nitrate or perchlorate and they can therefore be used as background electrolytes or ionic strength adjusters for sorbate solutions before performing potentiometric measurements.

Some interference by chloride ion might be expected as shown in Table 2. Concerning the food samples analyzed by the potentiometric sensor (soft drinks, skim yogurts, jams and sauces), it should be noted that analytical procedure adopted in this work is based on ethyl ether extraction of sorbic acid from acidified food matrices followed by its reversion to the aqueous phase (0.500 mol L^{-1} $KNO_{3(aq)}$; pH = 7.5 ± 0.1) as sorbate ion. The chloride content found in the last mentioned aqueous phase (which originates from the analyses of soft drinks, skim yogurts, jams and sauces) was always <1 μg L^{-1}, as analyzed by the mercury thiocyanate method (Williams, 1979). Therefore, the working procedure removes chloride interference.

Table 2
Selectivity coefficients $K_{SOB,M}$ for various anions[a].

Anion	$K_{SOB,M}$
Formate	1.2×10^{-4}
Acetate	2.1×10^{-3}
Propionate	2.6×10^{-3}
Citrate	2.8×10^{-3}
Fumarate	3.2×10^{-3}
Lactate	3.5×10^{-3}
Folate	2.8×10^{-3}
Benzoate	2.4×10^{-3}
Salicylate	3.1×10^{-3}
Chloride	8.6×10^{-2}
Sulphate	3.8×10^{-5}
Borate	3.2×10^{-5}
Perchlorate	No interference
Nitrate	No interference

[a] Selectivity coefficients were determined by matched potential method. See Section 3.4 for details.

3.5. Robustness of the proposed method

The robustness of the method was explained by the evaluation of the influence of small variation of some of the most important procedure variables including pH, potential range and measuring time.

Preliminary inspection of the results under various conditions suggested that the method is fairly robust, but the pH of the measuring solution should be in the pH range 6.0–9.0.

3.6. Analytical application

In order to check the usefulness of the proposed sensor for resolving real samples, we addressed the determination of sorbic acid in real food samples as soft drinks, skim yogurts, jams and sauces using a standard additions method (multiple addition method).

Table 3
Recovery study for sorbic acid spiked in real food samples.

Sample	Concentration added (mg/kg)	Concentration found (mg/kg)	Recovery [a] (%, ±SD)
Soft drink 2	10.0	9.8	98.0 ± 1.2
	50.0	49.7	99.4 ± 0.8
	75.0	74.3	99.1 ± 1.2
	100.0	100.9	100.9 ± 1.1
Skim yogurt 1	35.0	34.4	98.3 ± 1.2
	100.0	99.5	99.5 ± 1.0
	200.0	201.6	100.8 ± 1.2
	300.0	307.2	102.4 ± 1.1
Jam 1	30.0	30.4	101.3 ± 1.3
	100.0	100.8	100.8 ± 1.1
	200.0	197.4	98.7 ± 1.2
	300.0	298.2	99.4 ± 1.0
Sauce 2-ketchup	20.0	19.6	98.0 ± 1.2
	100.0	101.8	101.8 ± 1.3
	150.0	153.2	102.1 ± 1.1
	200.0	198.2	99.1 ± 1.0

[a] Average of six determinations ± standard deviation (SD).

Table 4
Sorbic acid determination in selected real food samples.

Sample	Electrode	Method	Comparative HPLC Method	
	Found [a] (mg/kg)	RSD [c] (%) (n = 6)	Found [a] (mg/kg)	RSD [c] (%) (n = 6)
Soft drink 1 (cola)	70.3 ± 1.3 t^b = 1.09 , F^b = 2.53	1.9	68.9 ± 1.1	1.6
Soft drink 2 (orange)	102.4 ± 2.0 t^b = 1.12, F^b = 2.74	2.0	103.2 ± 1.9	1.8
Soft drink 3 (lemon)	91.8 ± 2.0 t^b = 1.20, F^b = 2.79	2.2	89.9 ± 1.7	1.9
Skim Yogurt 1 (strawberry)	351.3 ± 6.6 t^b = 1.53, F^b = 2.82	1.9	356.8 ± 6.4	1.8
Skim yogurt 2 (tropical fruits)	298.6 ± 5.4 t^b = 1.35, F^b = 2.69	1.8	301.5 ± 5.1	1.7
Jam 1 (strawberry)	263.4 ± 5.8 t^b = 1.25, F^b = 2.78	2.2	259.9 ± 5.2	2.0
Jam 2 (peach)	240.8 ± 5.6 t^b = 1.34, F^b = 2.76	2.3	241.9 ± 5.1	2.1
Sauce 1-ketchup (hot)	302.3 ± 6.3 t^b = 1.39, F^b = 2.78	2.1	305.4 ± 5.8	1.9
Sauce 2-ketchup (plain)	202.7 ± 4.1 t^b = 1.33, F^b = 2.73	2.0	200.9 ± 3.6	1.8

[a] Values found are the average of six independent analyses (n = 6) ± the corresponding standard deviation (SD). Expressed as sorbic acid.
[b] Values of t and F at 95% confidence level. Theoretical values: t = 2.23, F = 5.05.
[c] Relative standard deviation (RSD).

In the proposed method, we demonstrated that the extraction procedures used to process real food samples as soft drinks, skim yogurts, jams and sauces (Sections 2.5.1 and 2.5.2) give quantitative results through the addition of know amounts of sorbic acid reference solutions in four representative food samples. The recovery experiments produced results ranging between 98.0% and 102.4% (Table 3).

Table 4 shows statistical analysis of the results obtained by using the presently proposed sorbate-sensitive electrode and the comparative HPLC method (Pylypiw & Grether, 2000) for determination of sorbic acid in food products. In all cases, the calculated F- and t-values did not exceed the theoretical values, indicating that there is no significant difference between either methods in concerning accuracy (t-test) and precision (F-test).

From the abovementioned results it is clearly apparent that the proposed sensor can be satisfactorily used for the determination of sorbic acid in food products such as soft drinks, skim yogurts, jams and sauces.

4. Conclusions

The results obtained in the present work demonstrate that the potentiometric method employing a sorbate-sensitive electrode immobilised in a graphite matrix may provide an attractive alternative for the determination of sorbic acid.

The proposed potentiometric sensor is relatively easy to prepare, exhibits long lifetime, show high sensitivity and wide dynamic range. Good selectivity, very low detection limit, rapid response and low-cost make this electrode suitable for analysis of sorbic acid in food products (soft drinks, skim yogurts, jams and sauces).

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