The value of rapid field kits for semi-quantitative assessment of the iodine content of salt in monitoring programs.

A. Melse-Boonstra[a], M.C.J. Quataert[a], C. v.d. Poll[a], J. Bulux[a,b], N.W. Solomons[b], C.E. West[a].

[a] Division of Human Nutrition and Epidemiology, Wageningen University, P.O. Box 8129, 6700 EV Wageningen, The Netherlands

[b] Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), Avenida 17 #16-89 (Interior), Zona 11, Guatemala City, 01011.

In order to detect the level of iodization in commercial salt rapidly, special test kits have been developed. We carried out two studies each involving two laboratories in order to determine their ability to classify salt as adequately or inadequately iodized. In the first study, 36 salt samples were analyzed with a rapid field kit with a detection range of 0-50 mg/kg iodine. In the second study, 50 salt samples were tested with a 0-30 mg/kg range kit, a 0-50 mg/kg, and a 0-100 mg/kg detection range kit. In one of the laboratories, the iodine level in the samples was also determined by titration, as a "gold standard" method. The specificity of the field kits showed to be high (76 to 100%), while the sensitivity ranged from 6 to 96%. Spearman correlation coefficients for the test kits versus the titration method were high in the first study (0.91 and 0.89, $P<0.01$) and somewhat lower in the second study (0.53-0.73, $P<0.01$). In the second study, all rapid field kits showed to overestimate the true iodine content of salt significantly (Wilcoxon signed rank test Z-scores -4.815 to –6.135, $P<0.001$). In conclusion, caution should be exercised in using field kits for rapid assessment of the iodine content of household salt because such kits tend to overestimate true iodine content. The kits constitute a specific measure for tracing non-iodized salt samples in monitoring programs, but many inadequately iodized samples will be described as containing sufficient iodine, limiting the sensitivity of the method.

1. INTRODUCTION

In 1952 the Republic of Guatemala promulgated legislation mandating fortification of salt with iodine using potassium iodate and since 1993 the iodine content of salt required is 30-100 mg/kg. The quality control of salt iodization through testing is critical to the overall success of any program for the elimination of iodine deficiency disorders. Quantitative laboratory methods for assaying the iodine content of salt are expensive [1]. Rapid colorimetric kits have been developed to provide semi-quantitative estimates of the iodine concentration of salt. These rapid kits can be used in the field and play an important role in salt monitoring programs [2,3]. However, there are different types and brands of these kits, designed to measure different ranges of iodine concentration (0-30 mg/kg, 0-50 mg/kg or 0-100 mg/kg). These various detection ranges cause confusion about which kit should be used. The purpose of the studies presented here was to determine the degree of agreement among different methods used to determine the iodine content of salt.

2. METHODS

2.1 Sampling

In the first study carried out in 1994, 36 salt samples of various brands were collected from 26 rural and 3 urban locations in Guatemala. In the second study carried out two years later, 50 salt samples of various brands were again collected, specifically from the region of San Pedro Sacatepéquez, a rural area close to the capital of Guatemala, Guatemala City. The sampling strategies in both studies were focused on diversity of the samples, but were not systematic or representative for the whole nation. In both studies, after semi-quantitative analysis of iodine content of the salt samples at the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) in Guatemala, the samples were packed and transported to the Centers for Disease Control and Prevention (CDC) in Atlanta, GA (USA), where the samples were analyzed both semi-quantitatively and quantitatively. The time between packing and analysis in Atlanta was less than 3 months.

2.2 Analytical methods

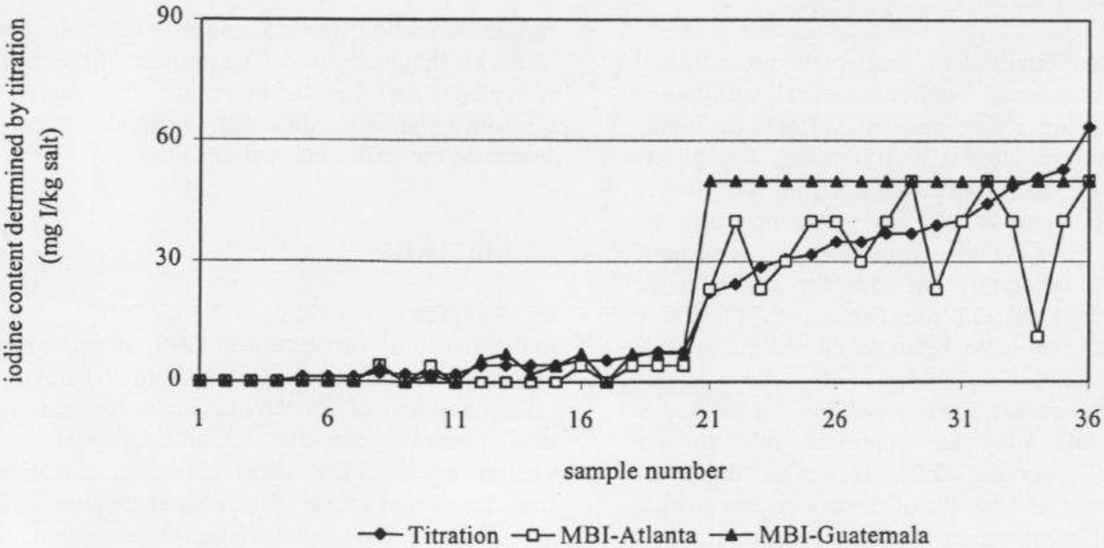
Three different semi-quantitative rapid field kits supplied by MBI Chemicals (Madras, India) were used. Each kit was designed for measurement of a specific range of iodine concentration and had a colour chart representing different values. The range of the kits, with the chart values in parentheses were as follows: 0-30 mg/kg (0, 7, 15, and 30 mg/kg); 0-50 mg/kg (0, 7, 15, 30, and 50 mg/kg); and 0-100 mg/kg (0, 25, 50, 75, and 100 mg/kg). Each kit comprised two ampoules with 10 mL test solution which is sufficient for 40-50 tests. The ampoules were packed in a cloth pouch together with a stainless steel spoon and plate, color chart and instruction notes. For each determination, a spoonful of salt is spread on the plate, a drop of well-shaken solution is dropped on the salt, and the colour adopted by the sample is compared to the colour chart and so the iodine range in the salt is determined. In the first study, the 0-50 mg/kg kit was used which was taken out of production in 1995. In the second study, all three kits were used.

The iodate content of salt samples was analyzed quantitatively in Atlanta by iodometric titration as described by Tyabji [4]: free iodine is liberated from the sample and then titrated with thiosulfate using starch as an external indicator. This technique is specific for iodate, and is unresponsive to iodide. According to Tyabji [4], the precision of the method has a coefficient of variation (CV of <15%, which is considered to be satisfactory [3]. Iodate concentration is expressed in iodine equivalents.

2.3 Statistical analysis

Sensitivity and specificity of the rapid field kits to classify adequately (>30 mg/kg) and inadequately (<30 mg/kg) iodized salt was calculated. Numbers of adequately and inadequately iodized salt samples as determined by titration and by each of the rapid field kits were grouped in two-by-two tables. Sensitivity was calculated by dividing the number of samples that were inadequately iodized as determined with both methods by the total number of samples which

Figure 1. Test results of iodine content of salt determined by titration and by rapid field kit (0-50 mg/kg) in Atlanta and in Guatemala, 1994.



were found to be inadequately iodized by titration. Similarly, specificity was calculated by dividing the number of samples which were found to be adequately iodized by both methods by the total number of samples which were found to be adequately iodized by the titration method. Spearman correlation coefficients were calculated to compare the rank-order correspondence of the iodine values between the semi-quantitative and the quantitative method. Wilcoxon signed rank test of the differences between the titration and field kit test results were used as a measure for under- or overestimation of iodine content of the salt samples by the field test kits. The statistical analysis was conducted using the SPSS software, version 7.5.2

3. RESULTS

In Figure 1, the test results of the analysis of salt samples by titration and by rapid field kit of the first study are shown. In Figure 2, the test results of the second study are shown.

As can be seen from Table 1, the specificity of the rapid field kits to classify adequately iodized salt (>30 mg/kg) correctly ranged from 76 to 100%, whereas sensitivity ranged from 6 to 96%.

Correlations between the quantitative and semi-quantitative methods were high in the first study: 0.89 and 0.91, $P<0.01$. In the second study correlations were somewhat lower and varied from 0.53 to 0.73, $P<0.01$, depending on the kit used

Figure 2. Test results of iodine content of salt determined by tritration and by rapid field kit (0-30 mg/kg, 0-50 mg/kg, 0-100 mg/kg) in Atlanta and in Guatemala, 1996.

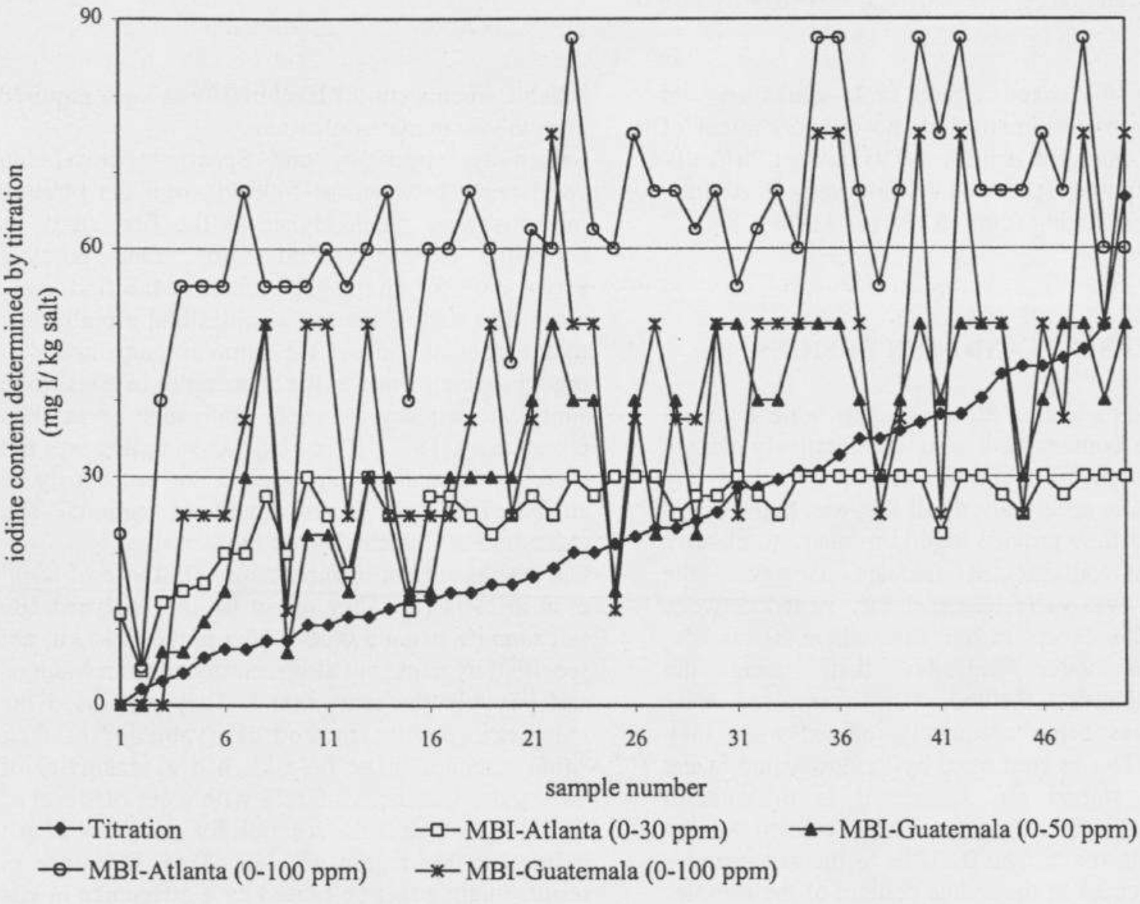


Table 1. Sensitivity and specificity of rapid field kits to detect adequate (>30 mg/kg) or inadequate (<30 mg/kg) levels of iodine in salt, Spearman correlation coefficients of the results obtained with the quantitative and semi-quanitative methods and Wilcoxon signed rank test scores.

		n	Sensitivity[1] %	Specificity[1] %	n	Spearman correlation coefficient	Wilcoxon signed rank test (Z)
First study:							
0-50 mg/kg:	Atlanta	36	96	85	34	0.89**	-1.298
	Guatemala	36	87	100	34	0.91**	-2.758**
Second study:							
0-30 mg/kg,	Atlanta	50	79	76	33	0.66**	-4.815***
0-50 mg/kg,	Guatemala	50	45	100	49	0.73**	-4.841***
0-100 mg/kg:	Atlanta	50	6	100	50	0.64**	-6.135***
	Guatemala	50	45	82	50	0.53**	-5.168***

[1]A level of 30 mg/kg iodine as detected with the rapid field kits was considered to be adequate.
Statistical significance: ** P<0.01, and ***P<0.001.

(Table 1). Wilcoxon signed rank scores showed significant overestimation of the iodine content of salt when using the rapid field kits, except for the 0-50 mg/kg range kit used in the first study in Atlanta, with scores ranging from - 6.135 to - 1.298 (Table 1).

4. DISCUSSION AND CONCLUSIONS

In this study a total of 86 salt samples were analyzed for iodine content both semi-quantitatively with a rapid colorimetric field kits and quantitatively by titration. The specificity of all kits was high, which means that they provide a good measure to classify adequately iodized salt samples. However, the sensitivity was variable. Sensitivity varied between 45 and 96% except in one case where it was 6%. This low value indicates that, using the semiquantitative method, the samples were classified as being adequately iodized when they were not. This is confirmed by the low value of the Wilcoxon signed rank score. It is difficult to attribute the discrepancy in the results to the observer, to the test kit itself or to the salt samples real differences in the iodine content of the samples measured in these two laboratories. Thus, our findings imply that the potential of these kits to identify inadequately iodized salt samples is not reliable when a cut-off level of 30 mg/kg is required as in the Guatemalan situation.

Sensitivity, specificity and Spearman correlation coefficients between the field kits and the titration methods were much higher in the first study as compared to the second study. One possible explanation for this might be that in the first study more than half of the salt samples had a really low iodine content (56%of the samples contained <10 mg/kg iodine), while in the 50 samples in the second study inadequacy of salt iodization was less pronounced (18% <10 mg/kg). As sampling was not done representatively this should not necessarily be attributed to any improvement of national salt iodization in Guatemala over the years.

Our results are not in agreement with those of Kapil et al in 1994 [5]. They report having analyzed 589 salt samples using a 0-30 mg/kg range field kit, not specified by name but also manufactured in Madras, and possibly the same brand. They also used the iodometric titration method of Tyabji [4] as their "gold standard". The field kit had a sensitivity of 96% and a specificity of 25% with a cut-off level of 15 mg/kg, which is the criterion for adequacy of salt iodine for that region of India. This difference in results might either be caused by a difference in kits or by sensitivity and specificity of the field kits being closely linked to the observer.

In conclusion, the field kits for rapid assessment of the iodine content of household salt as used in our studies tend to overestimate true iodine content. Rapid field kits provide a convenient measure for tracing non-iodized salt samples in monitoring programs, but at the same time they will probably regard many inadequately iodized salt samples as adequately iodized. It may well be that technical advances over the last few years have improved the ability of rapid field kits to identify salt which is inadequately iodized. Anyway, it is necessary that the quality of the rapid field kits, particularly with respect to sensitivity, should be checked by comparing the results observed using the kits with the titration method. This must become an essential feature of programs to monitor salt iodization.

ACKNOWLEDGEMENTS

We are grateful to the Program Against Micronutrient Malnutrition, Center for International Health, Emory University and of the Center for Disease Control and Prevention, Atlanta, GA, USA, and we kindly thank Sandy May and Glen Maberly for their cooperation with analyzing the salt samples in the Atlanta laboratory.

REFERENCES

1. Pandav CS, Anand K, Karmakar MG. Costing of a salt iodine monitoring laboratory in India. Nat Med J India, 1994;7:12-14.
2. M.G. Venkatesh Mannar MG, Dunn JT. Salt iodization for the elimination of iodine deficiency. ICCIDD, 1995.
3. Sullivan KM, Houston R, Gorstein J, Cervinskas J. Monitoring universal salt iodization programmes. UNICEF/PAMM/MI/ ICCIDD/WHO, Atlanta/ Ottawa, 1995.
4. Tyabji R. The use of iodated salt in the prevention of iodine deficiency disorders – A handbook of monitoring and quality control. New York, UNICEF/ROSCA, 1985.
5. Kapil U, Mayar D, Goindi G. Utility of spot testing kit in the quantitative estimation of iodine content in salt. Indian Pediatrics 1994;31:1433-1435.