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Detection of Baking Soda in Flat Bread by Direct pH Metery and Alkalinity Measurement

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Abstract: The objective of this study is evaluation of direct pH metery and alkalinity measurement methods for determination of baking soda in lavash bread (a kind of flat bread) in order to introduce and recommend a good practice of control. For running the experiments, various samples of lavash bread having different concentrations of baking soda were prepared. Ten grams of each sample were mixed with distilled water and then the prepared solutions were filtrated. The filtrates were then analyzed for pH and total alkalinity according to the distractions described in Standard Methods. Results show a significant correlation between the pH values of bread samples and the amount of baking soda. Also, a positive correlation has been observed between the alkalinity of bread samples and used baking soda. By comparing the R^2-values specified for these two methods it could be concluded that the direct pH metery method is more reasonable. Furthermore, by this simple method it is possible to accelerate the detection of minute amounts of this chemical in bread.

Key words: Baking soda, flat bread, lavash bread, alkalinity measurement, pH metery

INTRODUCTION

Bread is eaten mainly as a cheap source of energy and so it is the most important item in the Middle Eastern countries. It provides as much as 50-90% of total caloric and protein intakes of people living in the cities and villages. Iranian flat bread such as Lavash is mainly produced from soft white wheat flours of high extraction levels with little or no fermentation. Thus, it contains relatively high levels of phytate, which repeatedly interfere with the bioavailability of divalent minerals, notably zinc, magnesium, iron and calcium (Reinhold *et al*., 1975). Two types of fermentation by using sour starter or baking soda have been costomory in Iran. Although, active dry yeast is becoming popular and has substituted for sour starter and/or soda in many small bakeries and mechanized plants, sour starter and soda are still used extensively to leaven breads (Faridi *et al*., 1983). Good bread can be made from dough to which the adequate amount of yeast is added. The dough is then allowed to ferment and kept at desirable temperature for an appropriate period of time. Use of chemicals such as soda and/or large amounts of ordinary salt is a common practice for preparing desirable bread because these compounds accelerate the process of bread making, decrease the fluidity of gluten and increase the elasticity of dough (Malakootian *et al*., 2005).

Baking soda (sodium bicarbonate, $NaHCO_3$) is a white crystal powder or granule with MW 84.0 that begins to lose CO_2 at about 50°C and at 100°C it is converted into sodium carbonate (Na_2CO_3). The popularity of baking soda as a gas source is based on its low cost, ease of handling and relative tastelessness. Utilization of baking soda can change color and flavor of bread (Fox and Cameron, 1995). Also, this practice impairs health effects and it can be a cause of stomach trouble, malnutrition, increased blood pressure, allergies, etc. (Faridi *et al*., 1983; Rezakhah, 2002; Eivazzadeh, 2005). Baking soda intoxication produces multiple metabolic derangements and case reports have described a variety presentations ranging from mild gastroenteritis to seizures and even to cardiopulmonary arrest (Mennen and Slovis, 1988; Fitzgibbons and Snoey, 1999). Toxicity as a result of excess sodium bicarbonate has been reported and nephrotoxic effect of sodium bicarbonate overdosing was well documented (Davison and Wideman, 1992; Lloyd and Rose, 1995). In many bakeries of the Middle East, soda is used at the proportion of 1% (Faridi and Finney, 1980)

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which would make the impact of this chemical more pronounced. In this part of the world, bread constitutes a major part of the diet thus; high phytic acid content of the bread is suspected to be important factors in mineral deficiencies which are consider being the prevalent diseases in these regions (Brun *et al*., 1992; Rhou and Erdman, 1995). Some studies about baking soda in bread had previously been conducted in Iran (Malakoortian and Loloei, 2003; Amini *et al*., 2004; Zazooli *et al*., 2005; Jahed Khaniki *et al*., 2007). Therefore, elimination of soda as a leavening agent could significantly reduce the phytic acid content of their breads and increase availability of some minerals. For this reason, the Ministry of Health in Iran has prohibited the use of baking soda in flat breads (HMI, 2001). In this respect, applying the use of an appropriate method of determining baking soda in flat bread is recommended. This practice can be done by both pH metery and alkalinity measurement methods. The objective of this study has been to evaluate the suitability of these methods in determination of baking soda in lavash bread.

MATERIALS AND METHODS

Sample preparation: Lavash bread samples were all prepared from a single bakery plant and the amounts of baking soda additions in bread samples were designated to be 1, 2, 3 and 4 g of the chemical per kilogram of wheat flour in 2006. Samples for analysis were prepared by mixing regular amounts of necessary ingredients including flour, salt and water. After a process at 32°C for 60 min and obtaining 90% relative humidity, dough was divided into 250 g pieces and these were shaped into 1/32 inch thickness round-rectangular parts. All these dough pieces were then baked for 1-2 min at 330°C in a barrel-shaped oven (Faridi *et al*., 1982; Faridi, 1988; Rajabzadeh, 1994).

Sample examination: Ten gram of each bread sample was precisely weighed in a clean becker and 190 mL of distilled water was then added. The sample was mixed well by use of a magnetic stirrer. Then, this homogenous mixture was passed from Wattman filter paper No.1. After that, the measurement of pH was done by an electrical pH meter. Besides, alkalinity measurement was performed by titration of the filtrate with a standard solution of 0.1 M hydrochloride acid. For this work, 5 drops of bromocresol green indicator was added to a flask including 100 mL of filtered sample and the solution was titrated with 0.1 M hydrochloride acid to an intermediate green color. The volume of used hydrochloride acid solution was then recorded. At this point, the titration was stopped and the solution was gently boiled on a Bunsen burner. The solution was brought to a boil for 2 to 3 min. Then, the flask was cooled at room temperature before it was again titrated with 0.1 M hydrochloride acid to a yellow endpoint. The volume of used hydrochloride acid solution was again recorded. Finally, alkalinity level was calculated and reported as equivalent sodium carbonate. It was noticed that each mole of carbonate required two moles of acid for complete titration. Thereupon, two moles of sodium bicarbonate (baking soda) were converted to one mole of sodium carbonate at calculation. A blank was done just the same as the sample (Majedi, 1995; AWWA, 1998; Parvaneh, 2005). It should be noted that the process of detecting the endpoints of titration had also been checked electrometrically by means of a pH meter.

Statistical analysis: All the statistical methods have been done by use of the software SPSS, version 11.5 and Excel 2003. Besides, ANOVA analysis has been used after logarithmic conversion whenever necessary to detect significant differences among mean values.

RESULTS AND DISCUSSION

The pH and alkalinity levels of bread samples having different concentrations of baking soda are summarized in Table 1. This table shows the values of mean and standard deviation with respect to pH levels in lavash samples having 1, 2, 3 and 4 g baking soda per one kg wheat flour to be 6.31±0.17, 6.58±0.04, 6.72±0.15, 7.21±0.15 and 7.48 ±0.21, respectively. Also, similar amounts were calculated for alkalinity levels in lavash samples which were 52.33±5.99, 54.50±0.71, 60.50±5, 62±2.83 and 70.75±4.86. Figure 1 and 2 show the pH and alkalinity values versus the amounts of baking soda added to bread samples, respectively.

It is obvious that the addition of baking soda even in insignificant amounts in baking process of flat bread may have nutritional implications. Thereupon, drastic control of bakeries for soda use is recommended (Rastmanesh, 2002; WHO, 2002). This study shows that there is a positive correlation between the pH of bread samples and used baking soda which is statistically significant ($p = 0.002$, $R^2 = 0.972$) (Fig. 1). It should be noted that the added amounts of baking soda and pH are independent

Table 1: pH and alkalinity levels of bread samples having different concentrations of baking soda

Added baking soda (g kg^{-1})	No.	pH	Alkalinity (mg L^{-1})
0	6	6.31±0.17*	52.33±5.99*
1	6	6.58±0.04	54.50±0.71
2	6	6.72±0.15	60.50±5.00
3	6	7.21±0.15	62.00±2.83
4	6	7.48 ±0.21	70.75±4.86

*ANOVA: $p<0.05$, Values are shown as mean±SD

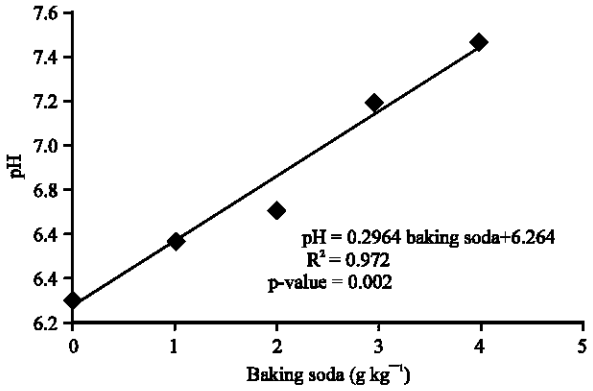

Fig. 1: pH values versus baking soda added to bread for direct pH metery method

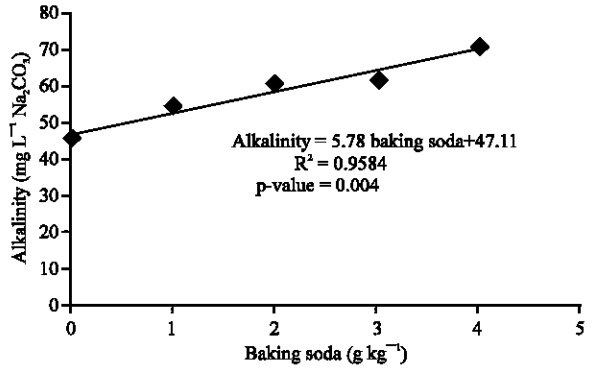

Fig. 2: Alkalinity values versus baking soda added to bread in electrometrical method

and dependent variables, respectively. These results clearly show that pH and alkalinity levels are increased in bread by addition of baking soda.

By use of pH metery method the precise value of pH which could be referred for indicating the probable consumption of soda in bread is above 6.26 (Fig. 1). The Institute of Standard and Industrial Research of Iran refers the pH = 6 as a border line for determining baking soda in lavash bread (ISIRI, 1999) and the bread quality control laboratories affiliated to the Ministry of Health utilize the pH more than 6 as an index for controlling the baking soda in lavash bread. On the other hand, according to Kargar and Mozaffari (2001) the pH = 6.4 has been reported to be a correct index. According to a study conducted by Jahed Khaniki *et al.* (2002) it was found that 60% of bakeries use baking soda in producing bread. The utilization rate of baking soda was different in various kinds of breads ($p<0.001$) and the highest frequency (82.6%) of using soda was belong to lavash bread.

Figure 2 shows a positive correlation between the alkalinity of bread samples and used baking soda which is considered to be significant ($p = 0.004$, $R^2 = 0.9584$) for electrometrical method. In this method, the amounts of baking soda added and resulted alkalinities (as mg L^{-1} Na_2CO_3) are independent and dependent variables, respectively.

The results of present study indicated that the pH and alkalinity levels in lavash bread are both increased with adding baking soda. By comparing the R^2 values specified for these two methods, the direct pH metery method is more reasonable to recommend, because pH variations in this method are more dependent on the amount of sodium bicarbonate addition. Besides, pH control can be accomplished very easy and much rapidly. Nevertheless, regarding similar experiments conducted by other researchers in this respect it should be mentioned that the pH determined from any of these procedures will probably not be exactly a precise number, but it should be close. So, there is often need to examine the obtained data and do some rounding off to find the nearest pH number.

CONCLUSIONS

It could be concluded that the direct pH metery method is more reasonable because pH variations in this method are more dependent on the amount of sodium bicarbonate addition. Therefore, utilization of pH metery method can be recommended for determination of baking soda in Iranian flat bread. Detection of baking soda could also be performed by alkalinity determination but it is not advised since this test requires additional chemical reagents and it is accomplished in much longer durations.

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