

Assessment of wheat flour fortification with iron and folic acid in flour factories of Zanjan province, Iran, 2016

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ABSTRACT

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Background: Fortification has an important role in the correction of dietary micronutrients deficiencies. The aim of the present study was to assess the fortification of wheat flour with iron and folic acid in Zanjan province.

Methods: Totally, 479 samples were obtained from active flour-producing factories in Zanjan (5 factories) in 2016. The rate of fortification in bakery products was measured with the spot test and UV spectrophotometric method and was compared with the standard values of Iran Food and Drug Administration (IFDA).

Results: Qualitative assessment of the iron content in Tafton/Lavash and Barbari flours revealed that the fortification program was successful in all the cases (100%) according to the standard values of the IFDA. Quantitative evaluations indicated that 72.68% and 68.46% of samples from Tafton/Lavash and Barbari flours, respectively, had iron concentrations in standard ranges (40-85ppm). The average concentrations of iron in Tafton/Lavash and Barbari flours were 62 and 57.91 ppm, respectively. According to the results, the average Iranian would receive about 7.5 mg/d of iron from the fortified wheat flour.

Conclusions: The results suggest that fortification of wheat flour with premix is in an acceptable condition in Zanjan province.

Introduction

Fortification, defined as adding micronutrients to processed foods in order to improve their nutritional quality, has a great significance for the prevention of

micronutrient deficiencies worldwide. Nowadays, the enrichment of foods with a variety of micronutrients is considered as one of the safest and most economical strategies for controlling different types of deficiencies all over the world [1]. Pregnant women, lactating women, and children are the most vulnerable group to micronutrient deficiencies [2]. Fortification of wheat flour started in the US and the UK about 60 years ago, and micronutrients such as iron, calcium, and B-group vitamins were added to flour. Currently, 85 countries around the globe have legislated rules and regulations related to wheat flour

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fortification and have the instructions to fortify it with folic acid and iron [3, 4].

Adding folic acid to flour cans prevent congenital defects of the neural tube [5]. Neural tube defect accounts for 60% of congenital defects in both live and dead births [6]. In the US, fortification of flour with folic acid has begun since 1996, which resulted in a 19% reduction in the incidence of congenital defects of the neural tube. Also, owing to the importance of folic acid in promoting general population health, this vitamin has attracted great attention. As an example, folic acid has a special role in decreasing homocysteine and may prevent cardiovascular diseases, stroke, etc. [7]. Consumption of 0.4 mg of folic acid both meets the daily requirement and prevents the incidence of neural tube defects in newborns [8].

Anemia is one of the most common diseases worldwide. According to the World Health Organization (WHO), around 1.62 billion people in the world are affected by anemia. Furthermore, pregnant women and children under 6 years of age in developing countries constitute the majority of the anemic population [9]. The prevalence of iron-deficiency anemia in Iranian pregnant women has been reported to be 14.2% [10].

Fortification of foods with iron is one of the best solutions for resolving the iron-deficiency anemia [11]. The most common foods which are used for fortification include cereals (especially wheat and corn), salt, sugar, and spices [12]. In many Eastern Mediterranean countries, because of high consumption of bread, flour is considered as a suitable food carrier, and the flour fortification program with iron is considered an effective strategy for decreasing the iron-deficiency anemia [13].

A premix containing ferrous sulfate and folic acid is used for fortification of wheat flour in Iran [14]. According to the WHO recommendations, premix should contain 30 ppm of iron (ferrous sulfate) and 1.5 ppm of folic acid for the fortification of flour [15].

Considering the high incidence of anemia and the available potential and facilities, flour fortification was pioneered in Bushehr province of Iran on May 31, 2001. Following the investigation of the results of the fortification program and considering its effectiveness in reducing anemia and iron deficiency in Bushehr, the nationwide program to fortify all bakery flours began in 2006 [16]. To ensure that all the flour factories are fortifying their products according to the established protocols, Iran's Food and Drug Administration (IFDA) took the responsibility of the supervision and sampling of their products. There are 5 flour-producing factories operating in Zanzan province of Iran (Figure 1). Given the necessity of monitoring the successfulness of flour fortification program, this research was conducted in 2016 with the aim of the qualitative and quantitative surveying of the flour fortification with iron and folic acid.

Methods

Sampling and testing

This study was performed on different types of bakery flour (namely, Taftoon/Lavash and Barbari flours) that were produced in 2016. A total of 479 flour samples were taken from 5 flour-producing factories under the supervision of the Food and Drug Department of Zanzan University of Medical Sciences. Of them, 238 samples were Taftoon/Lavash flour, and 241 samples were Barbari flour. Sampling was performed according to the Iranian

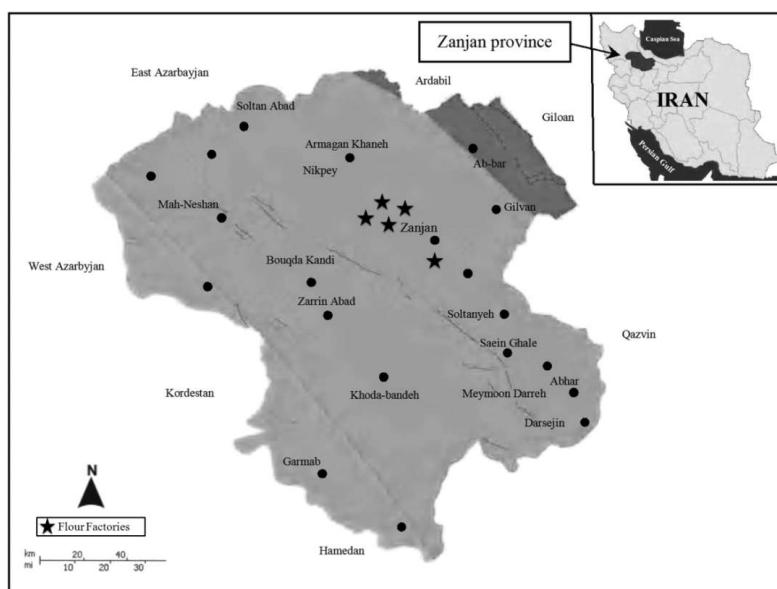


Figure 1. Location of the flour factories and study area

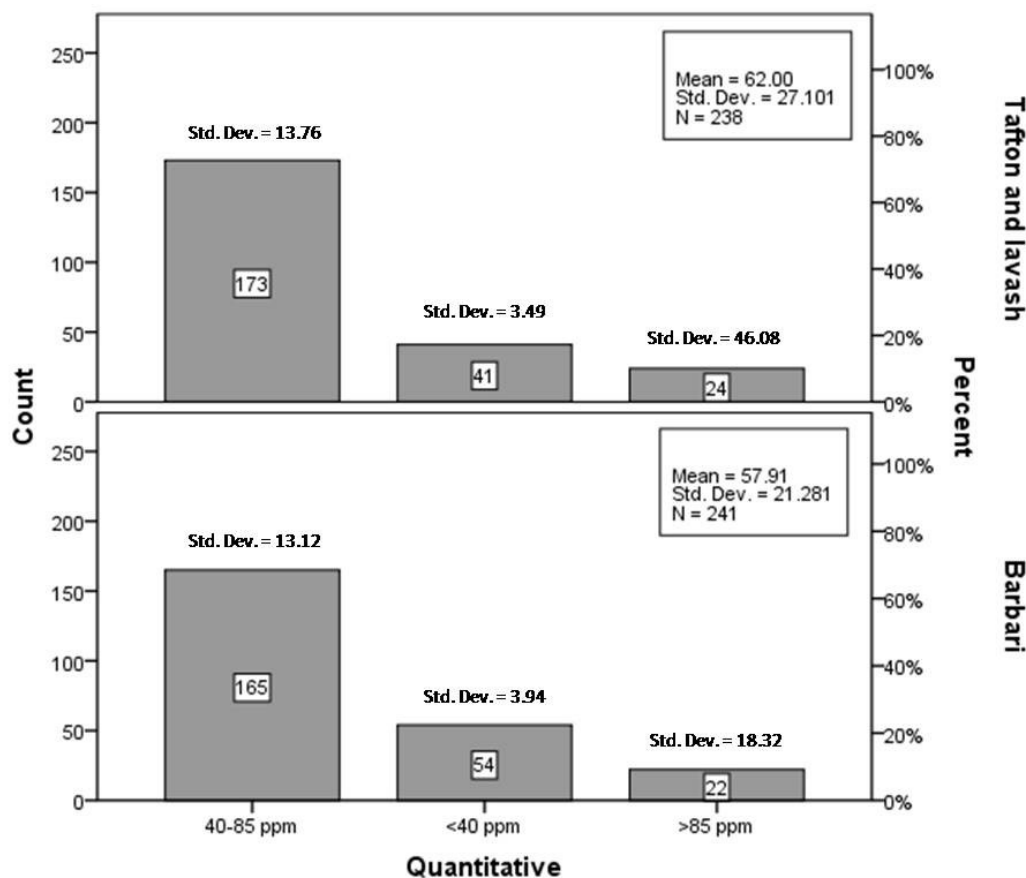


Figure 1. The success rate of fortification program for Taftoon/Lavash and Barbari flours in Zanjan province in 2016

national standard No. 13535 (Cereals and their products-sampling) [17].

According to the standard protocols, iron is typically used for the assessment of the adequacy of flour fortification [18]. According to the instructions of IFDA of the Ministry of Health and Medical Education, the level of premix injected into bakery flour by flour-producing factories should be about 200 ± 20 grams per ton flour. According to these instructions, the level of iron in bakery flour should be 30 to 90 ppm in semiquantitative assessments and 40 to 85 ppm in quantitative assessments.

There are two methods for the evaluation of iron levels in flour: semiquantitative/qualitative and quantitative methods. The semiquantitative or the spot test method is a simple and inexpensive method which provides a quick way to identify the presence of iron in flour. In this method, approximate levels of iron in flour can be estimated by comparing the intensity of color and the number of colored points. The quantitative method makes use of spectrophotometric techniques to provide more accurate estimates of flour micronutrient contents.

Sample preparations for the spot test were performed according to the standards of the American Association of Cereal Chemists (AACC) [19], and the

quantitative method was performed according to the instructions developed by the Association of Official Analytical Chemists (AOAC International) using spectrophotometry [20] by a spectrophotometer (UV-1800, Shimadzu, Japan). All chemicals used in this study were obtained from Merck KGaA (Germany).

Statistical analysis

The qualitative and quantitative data are reported as frequency (%) and mean \pm SD, respectively. To compare the differences between the groups, the one-way analysis of variance (ANOVA) and Kruskal-Wallis tests were performed. For further comparison between the groups, the Tukey post hoc test was used. The statistical analyses were performed using SPSS 18 (SPSS Inc., Chicago, IL, USA), and $p < 0.05$ was considered significant.

Results

Semi-quantitative (qualitative) assessment of fortification

As shown in Table 1, based on the semiquantitative/qualitative assessments, of iron shows that, except one Barbari flour sample (0.2%), the iron content in all samples from both types of flour was in the IFDA standard range (30-90 ppm).

Table 1. The success rate of flour iron fortification program in Zanjan province (semiquantitative method)

Factory	Number of samples	Dispersion of results within defined guidelines of IFDA				Success rate (%)
		< 30 ppm	30-60 ppm	60-90 ppm	> 90 ppm	
Taftoon/Lavash flour fortified with iron						
1	51	0	1	50	0	100
2	38	0	38	0	0	100
3	51	0	51	0	0	100
4	52	0	52	0	0	100
5	46	0	46	0	0	100
Barbari flour fortified with iron						
1	50	0	3	46	1	98
2	43	0	43	0	0	100
3	50	0	50	0	0	100
4	47	0	47	0	0	100
5	51	0	51	0	0	100

*There were significant differences between the flour factories of Zanjan province in the amount of fortified iron.

Table 2. Iron content of bakery flours produced at flour factories of Zanjan province (quantitative method)*

Factory	Number of samples	Dispersion of results within defined guidelines of IFDA			Success rate (%)	Minimum (ppm)	Maximum (ppm)	Average (ppm)	Standard deviation
		< 40 ppm	40-85 ppm	> 85 ppm					
Taftoon/Lavash flour fortified with iron									
1	51	0	39	12	76.4	55.42	144.28	79.68	14.32
2	38	0	32	6	84	48.60	268	81.99	43.70
3	51	19	32	0	62.7	28.50	83.07	44.63	12.52
4	52	5	41	6	78.8	28	134	61.61	20.74
5	46	17	29	0	63	30	78.94	45.56	9.86
Barbari flour fortified with iron									
1	50	1	36	13	72	34.89	101	76.92	12.89
2	43	1	40	2	93	33.51	170.64	63.01	22.48
3	50	21	29	0	58	20	85.51	43.50	14.28
4	47	5	36	6	76.5	26	112.20	62.44	20.21
5	51	26	24	1	47	29.95	113.50	44.90	15.06

*There were significant differences between the flour factories of Zanjan province in the amount of fortified iron.

Quantitative assessment of fortification

The success rate of fortification program for Taftoon/Lavash and Barbari flours were 72.68 and 68.46%, respectively (Figure 2).

According to Table 2, the mean concentrations of iron in Taftoon/Lavash and Barbari flours were 62 and 57.91 ppm, respectively, which are within the standard range of IFDA (40-85 ppm). The highest concentration of iron was 268 ppm and was seen in a Taftoon/Lavash flour sample, while the lowest concentration of fortified iron was 20 ppm, which was seen in a Barbari flour sample.

Discussion

Under the mandatory fortification program by IFDA, all flour-producing factories across the country are supposed to fortify their bakery flours (Taftoon/Lavash and Barbari flour) with iron and folic acid

Our findings indicate that the program for the fortification of wheat flour with iron and folic acid was relatively successful in Zanjan province.

According to the results of the semiquantitative method (spot test), only 1 out of 479 flour samples (0.2%) had the fortification level above the standard range of the IFDA (30-90 ppm), and the iron contents of the other samples were in the recommended range. However, the quantitative method (spectrophotometry) showed that the iron concentrations in 41 out of 238 Taftoon/Lavash flour samples (17.22%) were above, in 24 samples (10.08%) were below, and in 173 samples (72.70%) were within the standard range of the IFDA. Regarding Barbari flour, quantitative method revealed that 54 out of 241 samples (22.41%) had iron concentrations above the standard range, 22 samples (9.13%) below the standard range, and 165 samples (68.46%) within the standard range of the IFDA.

The process of wheat flour fortification includes adding, distributing, and homogenizing a specific and controlled amount of micronutrients to a specific amount of flour [18]. Some reasons for a dramatic increase or decrease in the amount of micronutrients are as follows: (a) Maladjustment of premix injection rate. The rate of injection and addition of

premix should be calculated based on the real flour production rate, and the micro feeder should be regulated in a way that it injects a precise weight of the premix per minute. (b) Lack of calibration of the micro feeder device and regular control of premix weight. (c) Keeping constant the flour production rate. The amount of addition of premix depends on the extent of flour production. Therefore, a constant flour production rate throughout the production line can be very important. (d) The amount of each micronutrient added to the flour and primary premix. Fortification in all flour-producing factories must be done according to the standards of the IFDA. These standards include the minimum value of each micronutrient in the primary premix and the final product. Therefore, if there is excess or deficiency of micronutrients in the primary premix, the fortification level is not controlled, or the natural micronutrients present in nonfortified flour are not taken into account, flour will be overfortified or underfortified [18].

In a study by Lashkarboloki et al in Golestan province, the mean iron level of bakery flour was reported to be 52.63 ppm, which is in line with the results of the present study. Moreover, the mean residual content of iron in nonfortified wheat flour was 23 ppm [21].

In a survey of flour iron and folic acid fortification program by the Food and Drug Department of Kurdistan University of Medical Sciences, 445 out of 457 samples of bakery flour analyzed with spot test were according to the related standards [22], which is in accordance with the findings of the present research.

In a study by Sadighi et al, the success rate of flour iron and folic acid fortification program was assessed in Bushehr and Golestan provinces in 2008. The investigators reported a success rate (compliance with the IFDA standards) of 90% in Bushehr and 94.1% in Golestan province [15]. Our analyses using spot test indicated that the success rate of the program in Zanjan province is nearly 100%. A possible explanation for the almost complete success of the fortification program in Zanjan province can be the strict supervision of flour-producing factories by the Food and Drug Department of Zanjan University of Medical Sciences.

It seems that the wheat flour fortification program was successful not only in Iran, but in other Eastern Mediterranean countries as well. In a 2008 issue of the *Morbidity and Mortality Weekly Report* published by the Centers for Disease Control and Prevention of the US, the greatest enhancement in the percentage of wheat flour being fortified was seen in the Eastern Mediterranean region, increasing from 5% in 2004 to 44% in 2007. The amount of wheat flour being fortified within the same period

increased from 90% to 97% in the Americas region, from 26% to 31% in the African region, and from 16% to 21% in Southeast Asia [23].

An important question can be raised here: How much iron can be provided by this fortification program? Results of a comprehensive study by the National Nutrition and Food Technology Institute of Iran showed that the mean per capita consumption of bread in the country was around 320 g/d [24]. According to the instructions of the IFDA, 200 ppm of premix (including 42% ferrous sulfate, 0.75% folic acid, and 57.25% corn starch) must be added in 1 ton of wheat flour. Given the weight percent of iron in ferrous sulfate (33%) and knowing that about 1.34 kg of Barbari and 1.23 kg of Taftoon/Lavash bread can be produced from 1 kg of wheat flour, an average Iranian would receive about 6.59 mg/d and 7.2 mg/d of iron from the Barbari and Taftoon/Lavash breads, respectively. The standard level of iron in wheat flour is 3.3 mg/100 g (8.25 mg of iron in 320 g of bread) [25]. Therefore, it can be expected that fortification of wheat flour with iron can supply about 14.84 mg/day and 15.45 mg/day of Iron depending on the type of bread consumed. Hence, our findings are in agreement with some earlier studies [26, 27]. The RDA values for iron in the adult population (19-50 years) are 8 and 18 mg/d for men and women, respectively [28].

About 7 mg/d of iron from the fortification program is a considerable amount that can help overcome the anemia problem. In a study by Siassi et al in 2001, the prevalence of anemia in region 9 of Iran (including Zanjan, Qazvin, Qom, and Arak provinces) in the age groups of 6 years, adolescents, pregnant women, and the middle-aged was 18.2%, 17.3%, 21.4%, and 14.5%, respectively. In 2012, the prevalence of anemia had a significant reduction and reached 9.9%, 9%, 14.3%, and 10.3%, respectively, in the above-mentioned groups [29].

A possible explanation for this significant reduction can be the mandatory wheat-flour fortification program. However, since iron can be considered a pro-oxidant metal, there are some concerns regarding the intake of this amount of iron, especially in men [30]. Further studies are needed to enlighten the pros and cons of the current fortification program.

Conclusion

The mandatory program for the fortification of bakery wheat flour with iron and folic acid, which is established by the IFDA of the Ministry of Health and Medical Education, was relatively successful in Zanjan province.

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