TECHNOLOGICAL ASPECTS OF FLOUR ENRICHMENT WITH IRON

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Abstract: At the international level there is a tendency of enriching food products with various nutritive factors in the food's population. There is a shortage of iron and introducing it in the bakery products proves to be a good method of fighting against its shortage. The high level of iron alters significantly the products sensory features. Iron as a ferrous sulphate does not alter the rheological features of dough. At very high levels of ferrous sulphate it has low effects as a reducing agent.

INTRODUCTION

Wheat is one of the most used plants as a raw material for producing food products exceeding even rice in the 70's[1]. Wheat has a higher nutritive level than refined flours and its products. Grinding is the processes by which most of the bran and germs, which are component rich in vitamins, minerals and other important nutrient. The nutritional value of refined flours is lower than whole flours. We must emphasize the presence of the presence of the phytic acid in high quantities in whole flours by this diminishing the bowel absorption of some nutrients (minerals). The vitamins and minerals found in flour are not highly bioavailability, meaning they are mostly not available to be absorbed by humans[5].

International health organizations have drawn attention to the deficiency in the world's food population and in some geographic, economic or in some segments of population. Iron deficiency is the most common nutritional deficiency in the world. Iron can be found in all human cells, especially in red blood cells. Although most anemia is caused by iron deficiency.

The World Health Organization estimates that 40% of the world's population is anemic[2], 75% of which is due to severe iron deficiency[3]. The decreased capacity produced by anemia is manifest in lower work productivity in men and women, decreased intelligence in children, and greater risk for low birth weight babies in pregnant women. Women and children are most at risk for iron deficiency because of their condition of high blood loss and high growth, respectively[4].

These are one of the reason for which human food needs iron enrichment of some food products used by all social classes. Wheat as different products (flour, bakery and pastry products, pastas, flakes, cakes, biscuits) is highly consumed by the population and from this reason wheat products are an excellent support for enriching the population's foods with various nutrients. To all these arguments we can add the relatively low cost of flour and the possibility of easily introducing the nutrients with a homogenous mixture[4].
Iron has been used for the flour enrichment since the 40's in the U.S.A., the 70's in U.K. ant the 90's in Switzerland. Nowadays over 90% of white flours produced in the states of North, Central and South America are iron enriched. The lowest level of iron enrichment is in the Eastern European and in N-E Asia states (less than 5% of produced flour)[4].
The iron used for flour enrichment can be in different types. The best is ferrous iron which is much more easily absorbed. Schricker and Miller[6] have studied iron's absorption (ferrous sulphate, ferrous orthophosphate, sodium and ferrous pyrophosphate, ferrous fumarate, iron ions reduced (with hydrogen and carbonyl) and iron reduced electrolytic. The samples have been compared with ferrous sulphate. The 7 samples have presented minimal differences in comparison to control sample, the orthophosphate having the lowest absorption. PAHO[7] recommends that there should not be used ferric pyrophosphate, ferric orthophosphate and large particle size elemental iron powders.
For the enrichment it is most often used ferrous sulphate, ferrous fumarate, electrolytic iron, carbonyl iron, chelated iron (iron-EDTA, iron glycinates). For the flours with a low ash content (<0.8%) the ferrous sulphate is more preferably used. Ferrous sulphate will be used to enrich the low extraction flour stored under to moderate temperatures (20 to 30ºC) and low relative humidity (<50%) for less than 3 month.
The addition of products which contain iron enrich iron content in this element but may influence positively or negatively the flours bakery properties and the biotechnological processes that take place during the bakery process. The aim of this study is to determine the way in which the ferrous sulphate addition influences the rheological properties of dough.

MATERIALS AND METHODS

The evaluation has been made on 10 commercial flours, noted from A to J, whose properties have been determined and shown in table 1. There have been chosen flours of type 650, the most common type of flour used in producing bakery products (common bread).

Table 1. Properties of flours samples

Sample	Moisture	Wet gluten	Deformation index	Absorption*
	%	%	mm	%
A	12,5	29,1	3	56
B	11,8	29,5	7	58
C	14,1	30,3	7	61
D	12,2	28	4	55
E	13,5	29,5	5	58
F	13,8	30,2	3	57
G	11,6	30,0	3	66
H	12,9	30,6	2	65
I	14,1	28,9	2	61
J	13,17	28,1	2	64

*determined at farinograph, in accordance with AACC Method 54-21, Constant Flour Weight (Variable Dough Weight) Procedure

The iron was introduced as a ferrous sulphate which is one of the most common and widely used forms of adding iron in flours for nutritional purpose. The ferrous sulphate has a very good solubility and is very well assimilate by the human body. The minimum level of iron in the fortified products is of 35 ppm (SUSTAIN[8]) and the maximum level is of 60 ppm as a ferrous sulphate or ferrous fumarate (PAHO[7]). The farinographic evaluation has been made with a ferrous sulphate addition in order to maintain a level of 30,1 mg Fe / kg flour, similar to the level assured by the introducing Roviforin F complex product, 44 mg Fe / kg flour equivalent to the U.S.A. imposed needs and 55 mg Fe / kg flour for Central and South America. For a better dosage and for avoiding iron oxidation this was mixed with flour for dilution. The necessary flour quantity enriched with iron was introduced in the farinograph retaining the same quantity from the sample. In order to influence lesser the farinograph characteristics of the samples, flour quantities replaced were reduced, 3, 4.4 and 5.5 grams.
For evaluation was used $FeSO_4 \times 7H_2O$, a.p.
The rheological characteristic of flours were evaluated using the Brabender Farinograph with mixing bowl for 300 g flour, in accordance with

Farinograph Method for Flour AACC Method 54-21, Constant Flour Weight (Variable Dough Weight) Procedure. There were determined:

- Dough Development Time: the time required for the curve to reach the maximum consistency range
- Stability: the time difference between point where top of curve first intersects and point where top of curve leaves 500 UB line or the line who define dough consistency
- Tolerance index: difference (in BU) from top of curve at peak to top of curve measured at 5 min after peak is reached
- Degree of softening: difference (in BU) between the maximum consistency and the dough consistency at 12 min after the peak
- Dough consistency: line range which passes through the middle of the curve at the maximum consistency
- Dough elasticity: the curve width at the maximum consistency range.

RESULTS AND DISCUSSION

The rheological effects of iron addition of ferrous sulphate are inconsistent and contradictory. The rheological characteristics of some sample are worsened while others are improved.

The worsening or improving of rheological characteristics is not proportional to iron rise quantity, with no correlation between these parameters and the iron level addition.

Figure 1 present of iron addition effects on dough development time, stability, tolerance index, degree of softening: difference, dough consistency and dough elasticity. There is showing the iron effect on every flour sample but also an average of those. Figure 2 shows only average values of these parameters.

The dough development time (Figure1.a) in most of the cases shows a slightly tendency of reduction. The average shows a slight tendency of reduction of dough development time from 2.3 min for control sample (0 mg Fe / kg flour) to 2 min for addition sample of 55 mg Fe / kg flour.

Dough stability (Figure 1.b) shows a slight reduction too if the addition quantity is raised. For some samples (A and C) can be seen a slight rise of their stability but their average it reduces from 12.1 to 11.5 min. It is not significant.

The tolerance index (Figure 1.c) shows a slight improvement. For the addition of only 30 mg Fe / kg flour the tolerance index rises with a slight worsening of dough properties. This worsening does not maintain because in high iron doses it may be seen a tolerance index reduction. The tolerance index diminishes on average from 51 BU (Brabender Unit) for the control sample to 40 BU for the enrich sample of 55 mg Fe / kg flour.

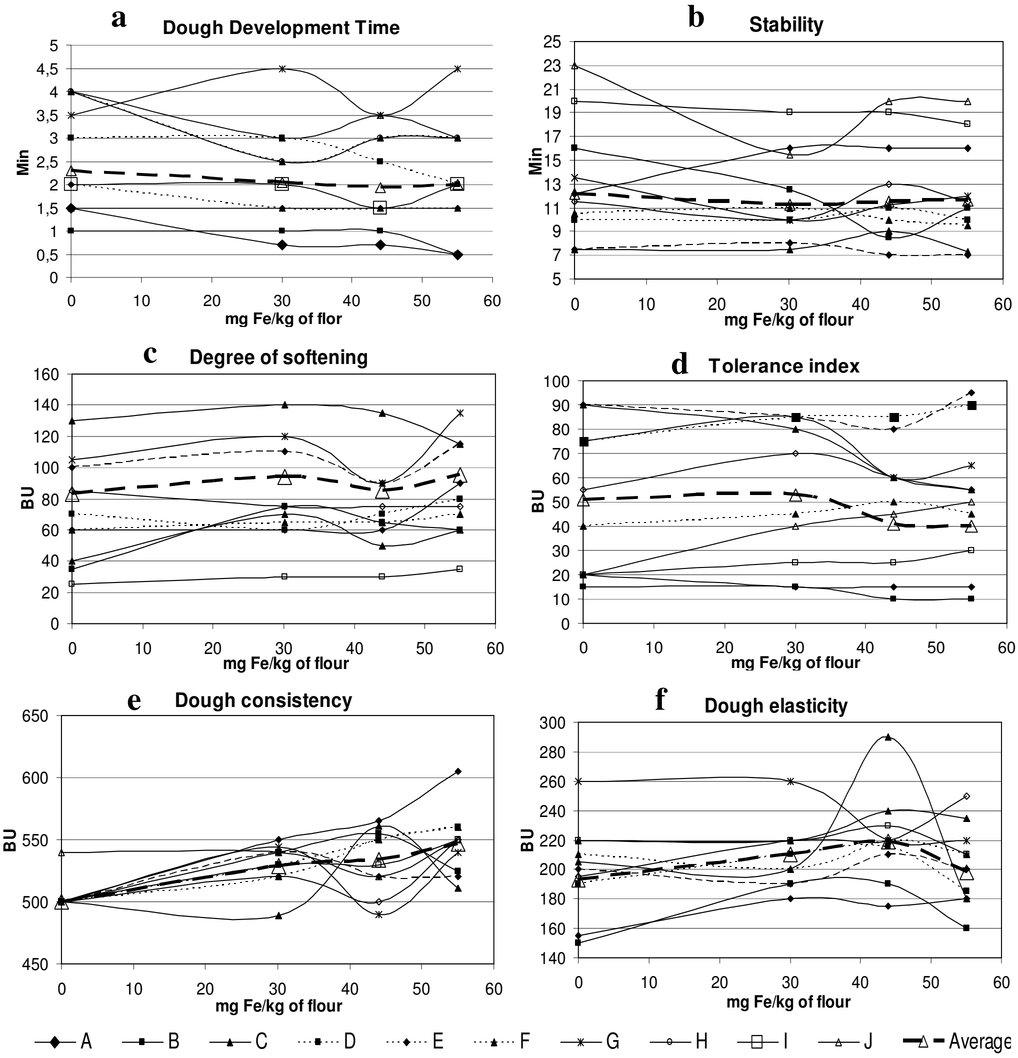

Figure 1: Rheological characteristics of sample at different range of iron addition

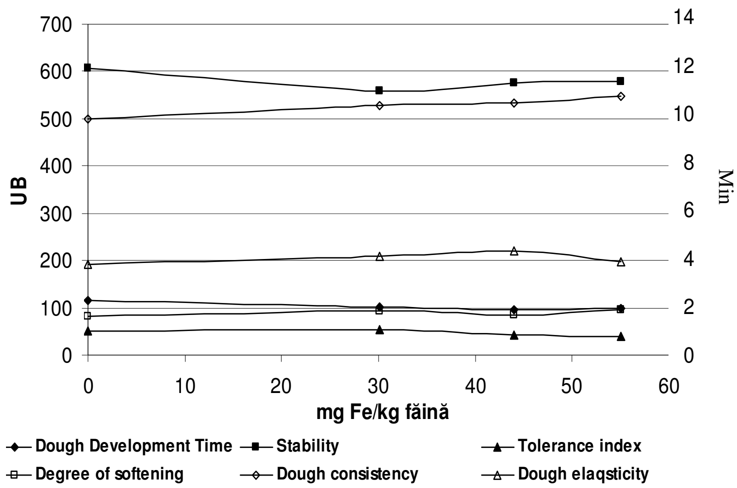

Figure 2: The average of rheological effects of iron addition

After 12 min from the peak the consistency of enriches dough shows a more emphasized degree of softening than those without iron addition. The outcome can be shown in figure 1.d. The degree of softening rises from 83 BU for the control sample to 95 BU for the sample with 55 mg Fe / kg flour addition.

The dough consistency (Figure 1.e) has a general tendency of rise along with the Iron addition from 500 BU for the control sample of 546 Bu for the sample with 55 mg Fe / kg flour. Same sample (E, G, H and J) show a reduction of consistency for the addition of 44 mg Fe / kg flour and than rise again for the addition of 55 mg Fe / kg flour.

The dough elasticity (Figure 1.f) rises in small doses and then reduces to the initial level when the iron quantity rises. It rises from 193 BU to 210 BU and then reduces to 198 BU.

Figure 3 presents farinogrammes for two flour sample (H and I) for an addition of 0 mg Fe / kg flour and 120 mg Fe / kg flour, a doses of 4 times higher than that of Roviforin product. In Table 2 the rheological characteristics of this evaluation are presented.

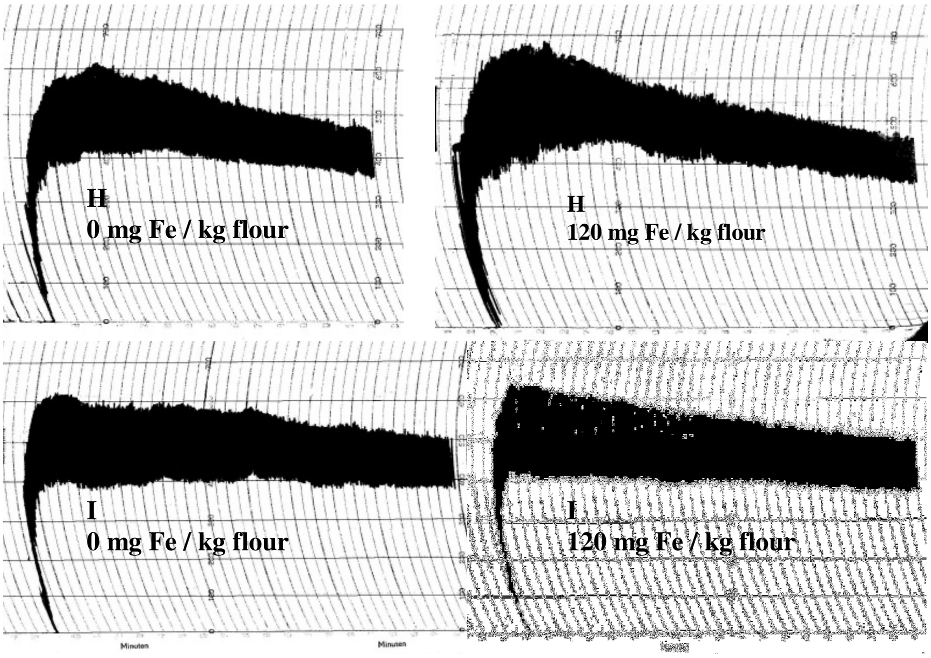

Figure 3: Farinogrammes of samples H and I at 0 and 120 mg iron / kg flour addition

Table 2. Rheological characteristics of H and I sample at 0 and 120 mg Fe / kg flour addition

Fe level	1		2		3		4		5		6	
	H	I	H	I	H	I	H	I	H	I	H	I
0	4	2	11,5	20	55	22	83	27	500	500	194	220
120	3	1,5	11	16	83	16	88	55	538	516	277	220

1 - Dough Development Time, min; 2 – Stability, min; 3 - Tolerance index, BU; 4 - Degree of softening, BU; 5 - Dough consistency, BU; 6 – Elasticity, BU

This evaluation point out the idea that iron in high quantities acts as a reducer but still different. One can see a reduction of dough development time, stability, and degree of softening similar to a reducer agent but its consistency and elasticity of the dough rises which is contrary to a reducer's action.

CONCLUSIONS

The results are inconsistent and some additional studies would be necessary. However the results show the following conclusions: the iron addition as ferrous sulphate in dough does not influence clearly the rheological characteristics oh the dough. Negative effects can be seen only al very higher doses of ferrous sulphate, doses which would negatively influence the taste and the color of the bread. Consequently ferrous sulphate may be introduced in bakery products without damaging the dough characteristics. Producers should not restrain from iron enriching products.

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