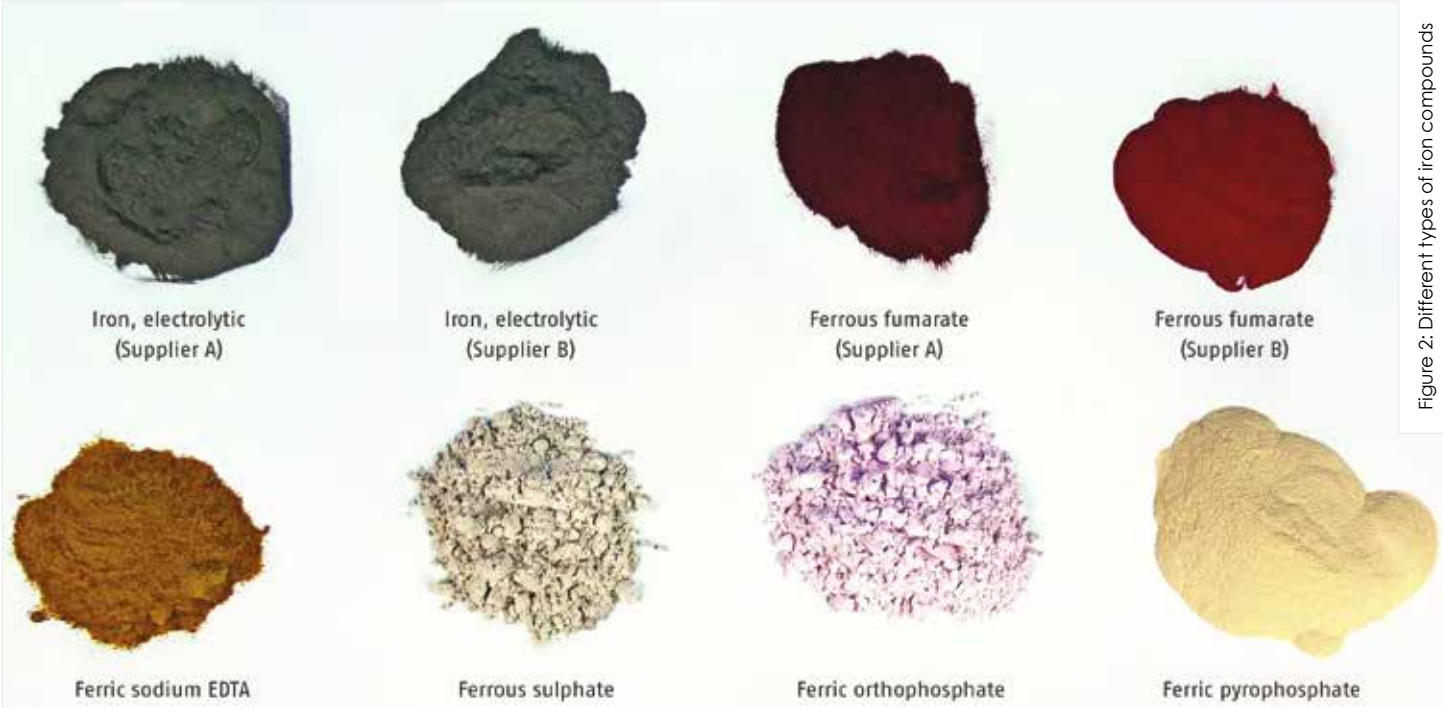

Figure 2: Different types of iron compounds

Fortification

effect of different iron compounds on the colour of dried noodles and pasta

by Lena Kampehl and Martina Mollenhauer, Mühlenchemie GmbH & Co KG

Every year, 600 million tons of wheat and maize flour are produced and consumed in the form of noodles, bread and other flour products. Fortification of industrially produced wheat and maize flour is therefore a simple and effective way of providing the world's population with vitamins and minerals. Industrially produced flour is defined as products from mills with a capacity of more than 20 t/day.

According to the FFI, nutrients are added to about 30 percent of all industrially produced flour worldwide. It estimates that 97 percent of the wheat flour in America, 31 percent in Africa, 44 percent in the Eastern Mediterranean, 21 percent in South-East Asia, six percent in Europe and four percent in the Western Pacific regions are fortified.

The consumption of flour with added vitamins and minerals is a significant step towards preventing micronutrient deficiencies.

The cost of flour fortification is more than made up for by savings in the public health system.

In the United States, fortification is credited with preventing 1,000 neural tube defects a year. Annual fortification costs are approximately US$ 3 million, and direct medical costs averted are US$ 145 million per year; consequently US$ 48 is saved for every dollar spent on fortification.

One indication of the success of flour fortification is that at least law in 82 states now prescribes the addition of iron or folic acid to flour. Three countries follow the recommendations of the World Health Organisation (WHO) voluntarily, and in 22 countries including Turkey, statutory flour fortification is in the planning phase. In 2004 only 33 states took part.

There are very different approaches to regulating fortification. It is important to consider the eating habits and nutrient deficits in the country concerned. Some countries fortify all flour with micronutrients, which means that all the resulting products benefit. Other countries treat flours according to the purpose for which they are used, so there are differences between bread and pasta flour, for example.

> "Fortification of industrially produced wheat and maize flour is therefore a simple and effective way of providing the world's population with vitamins and minerals"

There are also different recommendations for the minerals to be added. Whereas some countries only specify the quantity, for example of iron, others state, which iron compound, is to be used, e.g. ferrous sulphate.

The following tests were carried out because the use of ferrous sulphate is prescribed compulsorily in one Latin American

country. When fortified flour was used in noodle production, the boiled noodles were found to have noticeable grey discolouration, which was not acceptable to consumers.

Six different iron compounds were used in the series of tests.

The dosage used was 60ppm iron, since this is the highest level in the flour fortification standards. The 60ppm iron were converted for the iron compounds according to molecular weight, added to the flour and mixed with it.

The differences in the uptake of iron into the bloodstream (bioavailability) were not taken into account in the tests. In practice, however, it is usual to adjust the dosage of the iron compounds to their bioavailability, so that similar amounts of iron are available in the bloodstream.

For production of the spaghetti, a hard wheat with 12 percent protein was used. The water content of the noodle dough was 32 percent. In the laboratory the spaghetti was pressed with a Sela pasta machine, type TR 75 W, and dried for 24 hours at 35 °C and 60 percent relative humidity. 100 g pasta were then placed in 1 litre of boiling water with 5g salt and boiled for 8 minutes. The dried and the boiled noodles and also the water in which they were boiled were compared visually (Table 1).

Iron source	Non-enriched	Ferric phos
Relative bio-availability, % (WHO)		21
Appearance compared to non-enriched pasta		Comp
Pictures		

Ferric pyrophosphate, ferric orthophosphate and electrolytic iron had no effect on the colour of the noodles. With ferrous fumarate and ferric sodium EDTA the noodles were lighter in colour and less yellow, and with ferrous sulphate they had a noticeable greyish tinge.

The reasons for this presumably lie in the reactivity of the iron. An analysis of the water used for boiling also suggested reasons for the differences in colour.

In ferric pyrophosphate and ferric orthophosphate the iron is in a trivalent form and chemically inert. It does not enter a reaction. Since the products are not soluble in water, they are not washed out in the cooking process, and the noodles remain similar in colour to the untreated controls.

The divalent iron in the sulphate and fumarate enters redox reactions with the colour-giving substances of the flour, e.g. carotenoids, and this results in colour changes. Ferrous sulphate is more readily soluble in water than the fumarate, and thus more reactive. The colour deviation of the boiled pasta is therefore more noticeable than when fumarate is used.

The ferric sodium EDTA forms a complex with the pigments, which are partly washed out when the pasta is boiled. This is further confirmed by the loss of 40% of the iron through cooking. The boiled noodles were the lightest in colour in the comparative test.

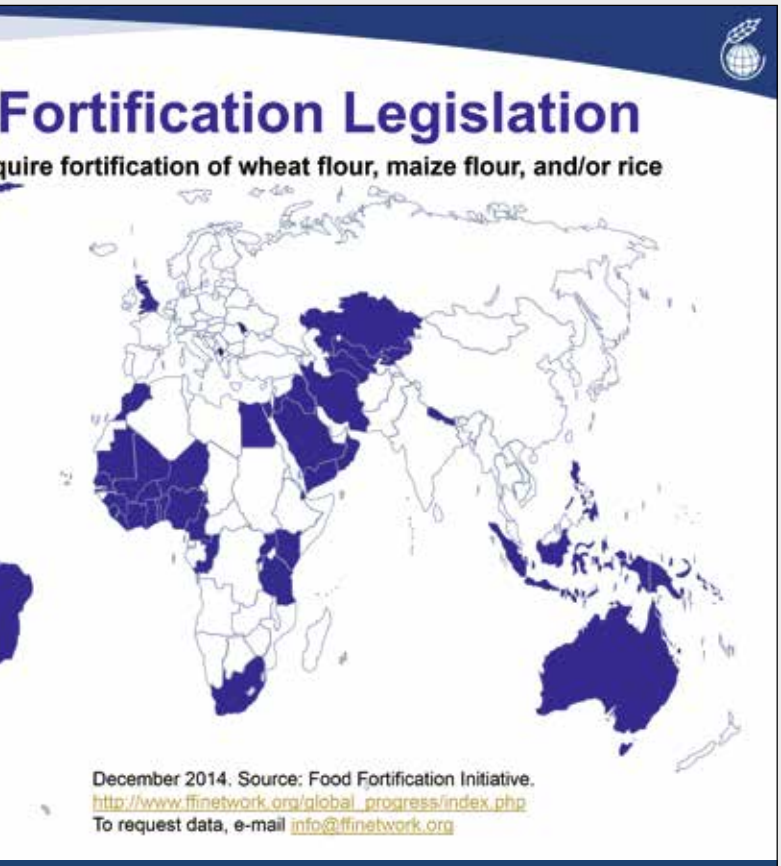

Figure 1: Status of flour fortification in December 2014. 82 states require the fortification of flour with at least iron and/or folic acid (Source: FFI, 2014).

pyro-phate	Ferric ortho-phosphate	Electrolytic iron	Ferrous fumarate	Ferric sodium EDTA	Ferrous sulfate
-74	25-32	50-75	100	>100	100
arable	Comparable	Comparable	Brighter	Much brighter	Greyish

Table 1: Changes in the colour of noodles caused by different iron preparations

Following the above results, the use of ferric phosphate for fortifying pasta flour was permitted in the country concerned, and consumer acceptance was restored.

References:

[1] *FFInetwork.org - Food Fortification Initiative*

[2] *WHO Recommendations on Wheat and Maize Flour Fortification, Meeting Report: Interim Consensus Statement, 2009*

[3] *Grosse, Scott, et. al., Reevaluating the Benefits of Folic Acid Fortification in the United States: Economic Analysis, Regulation, and Public Health. American Journal of Public Health 95 2005:1917-1922.*