Iron sources and their properties with regards to Flour Fortification

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Annette Büter
Technical Applications Manager – Flour Fortification

Mühlenchemie is a member of the Stern-Wywiol Gruppe

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Agenda

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- Introduction to iron
- Iron sources in different applications:
  - Bakery
  - Pasta
  - Noodles
- Interactions of iron with flour improvers

Introduction to iron

Iron compounds for flour fortification

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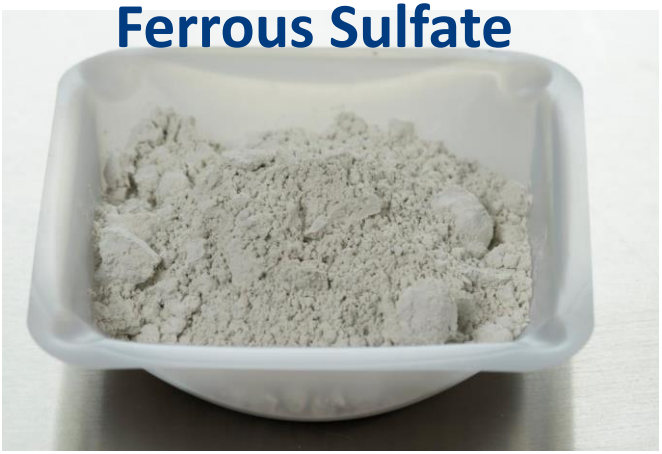
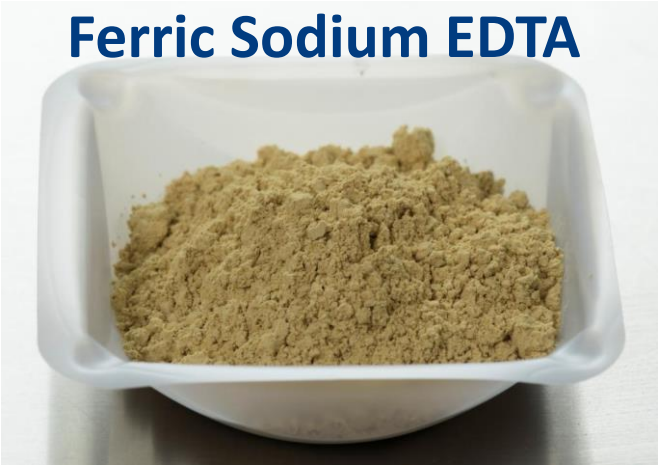
Electrolytic iron

Ferrous Fumarate

Ferrous Sulfate



Ferric Sodium EDTA



Introduction to iron – iron compounds

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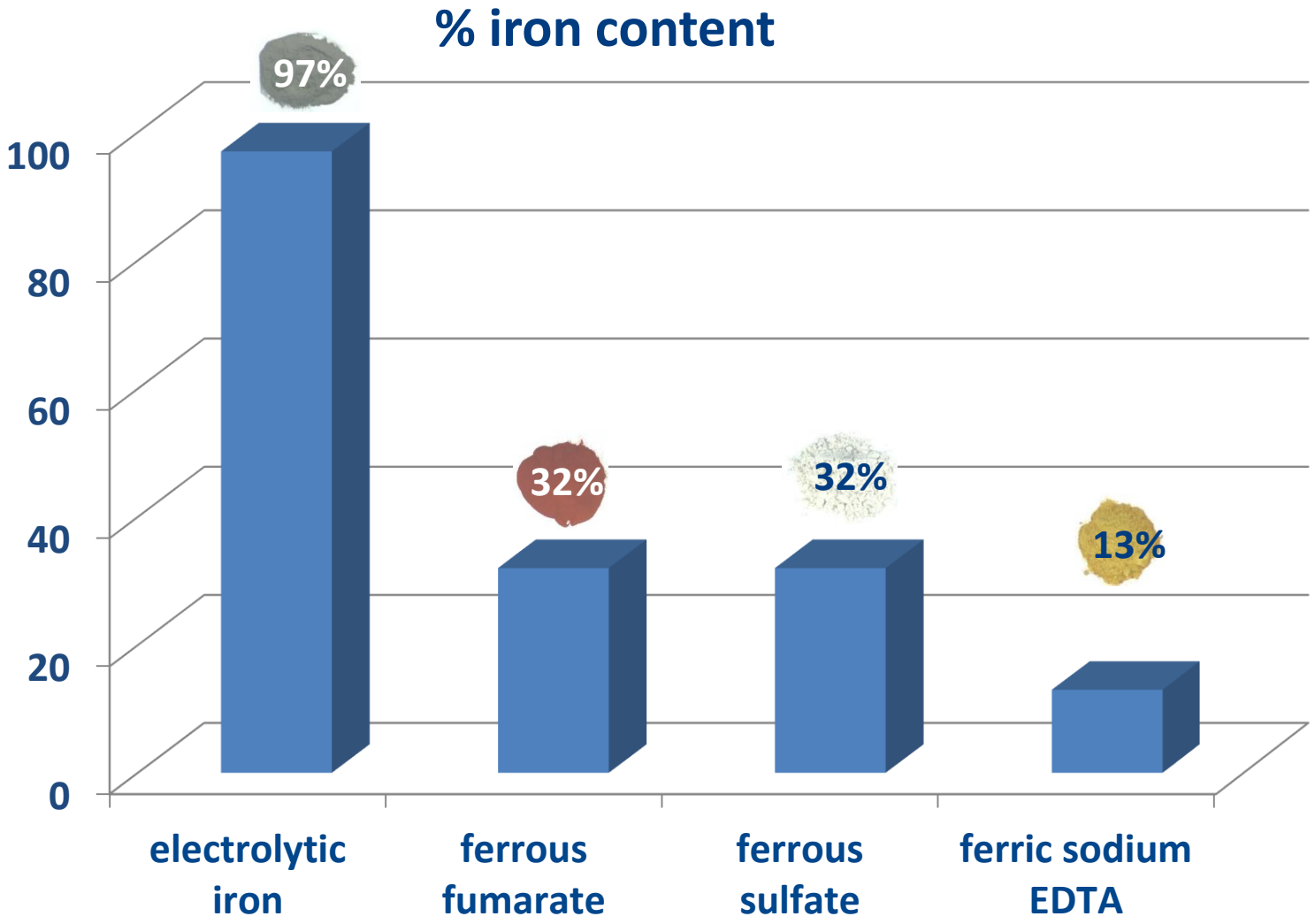

Introduction to iron – iron compounds

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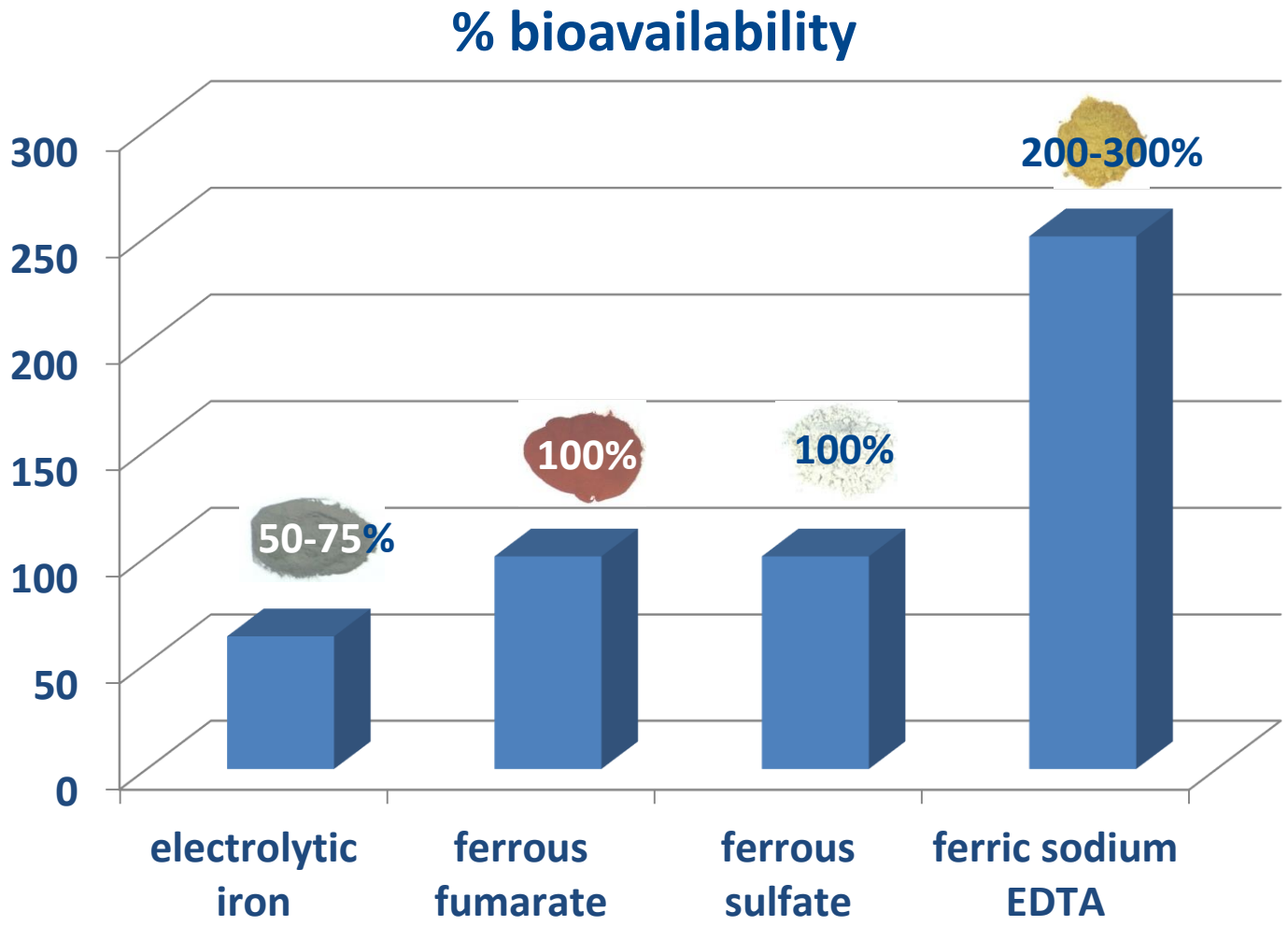

Iron compounds in different applications

1. Bakery

Case study – Chile

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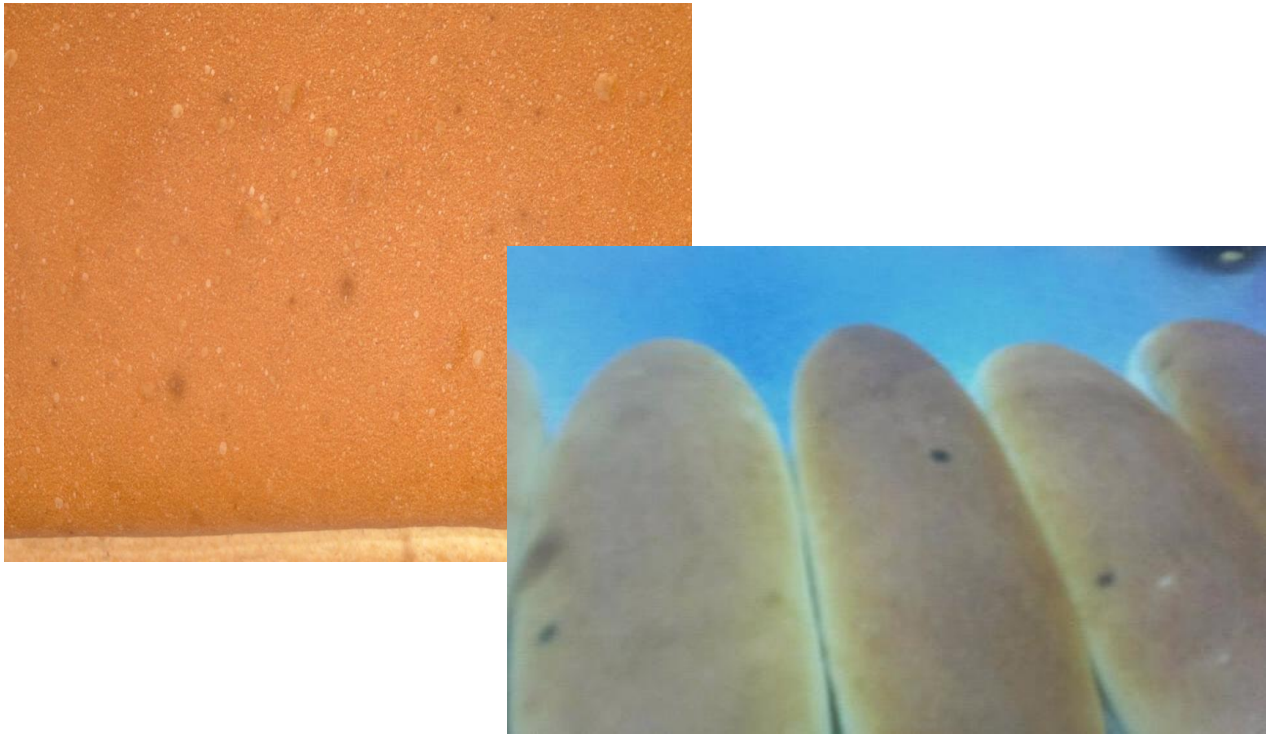
Spots on hot dog rolls



Case study – Chile

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Initial data

- Customer used ELCOvit 2035 RCH
- Dosage: 200 ppm, thereof 30 ppm iron from ferrous sulfate

Discussion

- Coarse ferrous sulfate can cause spots on bread crust

Case study – Chile

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Formation of dark spots by a too coarse ferrous sulfate powder

Fine powder Coarse powder

Case study – Chile

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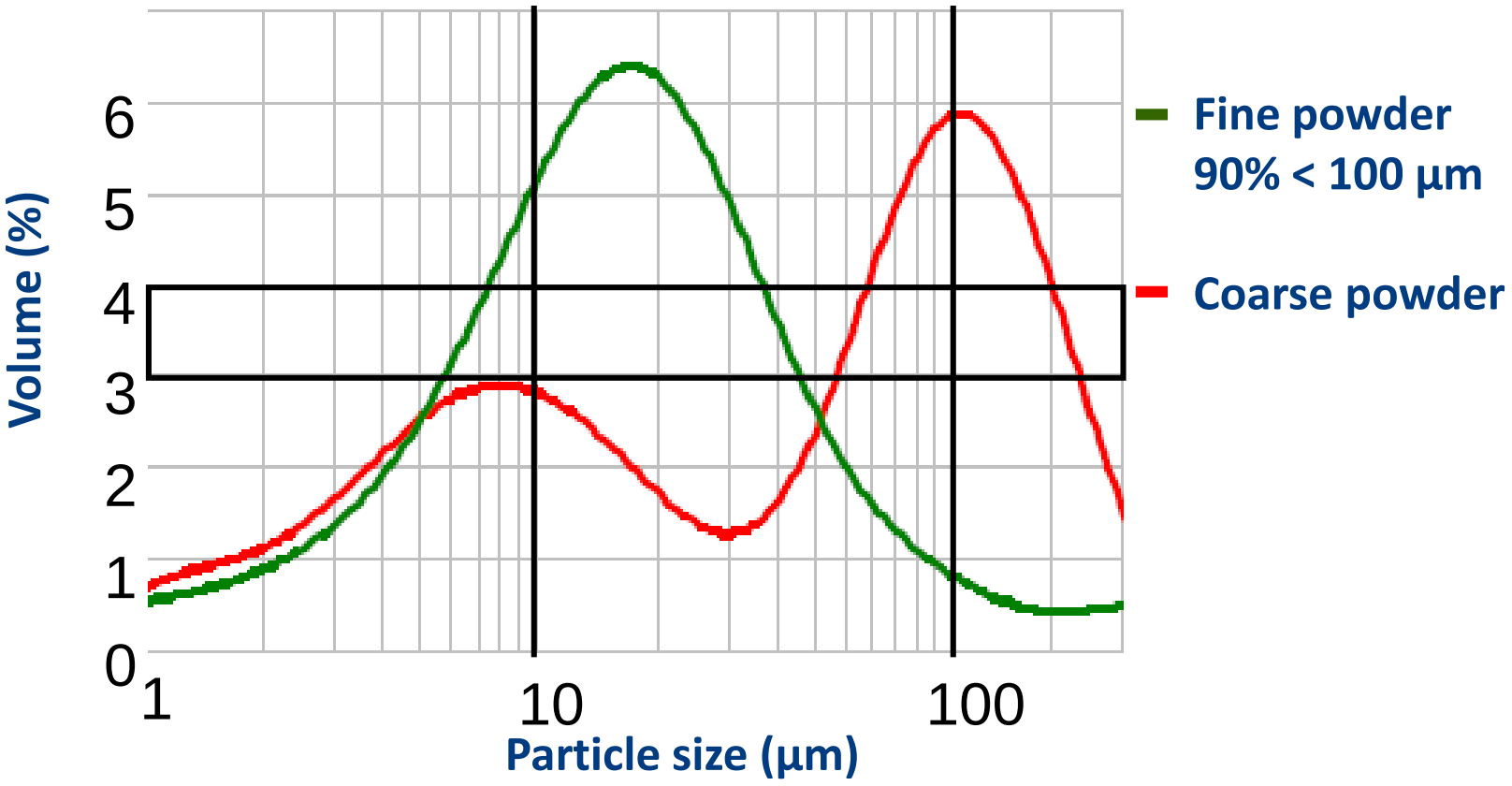
Different particle sizes of ferrous sulfate



Case study – Chile

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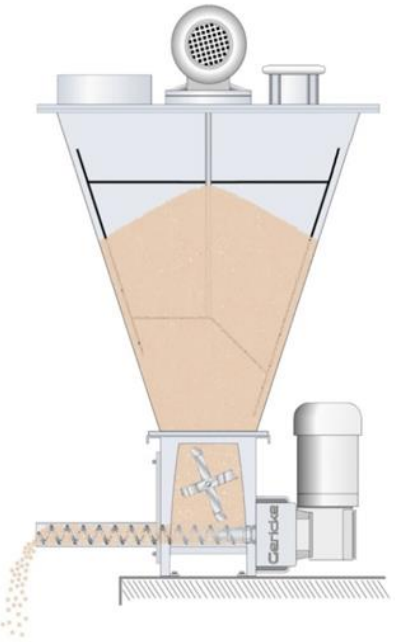
Discussion

- Coarse ferrous sulfate can cause spots on bread crust
- Granulation in all our premixes is very fine (90%<100µm)
- Batch was also delivered to other mills BUT
- No other complaints were filed

Case study – Chile

Cause

- Premix was kept in the feeder under humid conditions over a long period
- Agglomerates were formed



Action

- Sieving of flour
- Increase of free flowing agent in premix

Case study – Chile

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- Free flowing agent – functionality
- Extremely fine particles (SiO_2: ø13-20 µm)
- Absorption of humidity
- Keeps particles at distance

Case study – Chile

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- **Our recommended premix storage conditions:**
  - Low humidity (DRY)
  - Out of direct light (DARK)
  - Below 25°C (COOL)

Iron compounds in different applications

2. Pasta

Impact of iron sources on pasta

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- **Trials in pasta to find out impact of different iron sources**
  - Spaghetti made from untreated hard wheat flour and water
  - Flour was fortified with 60 ppm iron in all trials
  - Control or reference: pasta with non-fortified flour

Sample	0	1	2	3	4	5	6
Iron source	Non-fortified	Ferric pyro-phosphate	Ferric ortho-phosphate	Electrolytic iron	Ferrous fumarate	Ferrous sulfate	Ferric sodium EDTA
% Relative bio-availability	n.a.	21-74%	25-32%	50-75%	100%	100%	>100%
% Iron content	n.a.	24%	26%	97%	32%	32%	13%

Impact of iron sources on pasta

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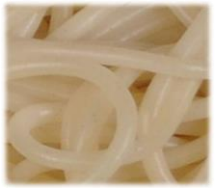
Results of different iron sources in pasta

Sample	0	1	2	3	4	5	6
Iron source	Non-fortified	Ferric pyro-phosphate	Ferric ortho-phosphate	Electrolytic iron	Ferrous fumarate	Ferrous sulfate	Ferric sodium EDTA
% Relative bio-availability	n.a.	21-74%	25-32%	50-75%	100%	100%	>100%
% Iron content	n.a.	24%	26%	97%	32%	32%	13%
Pasta cooked							
Appea-rance vs 0		Com-parable	Com-parable	Com-parable	Brighter	Greyish	Much brighter

Iron compounds in different applications

3. Noodles

Impact of iron sources on noodles

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- **Trials in alkaline noodles to find out impact of different iron sources**
  - Noodles made from untreated low protein/ash wheat flour, salt, water, alkalines
  - Flour was fortified with iron levels according to WHO recommendations
  - Control or reference: noodles with non-fortified flour

Sample	0	1	2	3	4	5	6
Iron source	Non-fortified	Ferric pyro-phosphate	Electrolytic iron	Ferrous fumarate	Ferrous sulfate	Ferric sodium EDTA	Ferric sodium EDTA
Added amount of iron - ppm	n.a.	60	60	60	60	40	20

Impact of iron sources on noodles

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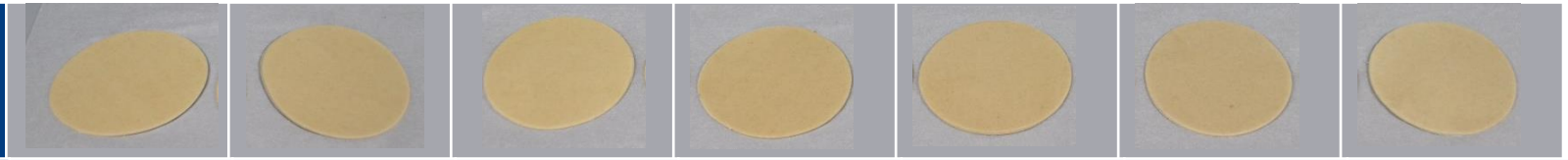
Results of iron sources in alkaline noodles

Sample	0	1	2	3	4	5	6
Iron source	Non-fortified	Ferric pyro-phosphate	Electrolytic iron	Ferrous fumarate	Ferrous sulfate	Ferric sodium EDTA	Ferric sodium EDTA
Added amount of iron - ppm	n.a.	60	60	60	60	40	20
Dough after 24h							
Noodles cooked							
Appea-rance vs 0		Com-parable	Com-parable	slightly darker, less yellow	darker, less yellow	perceptibly darker, less yellow	comparable

Examples of interactions with iron

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Interactions of iron with flour improvers

Flour improver: Ascorbic acid

Interactions - flour improver & fortificants

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- Storage trials: Blend of ascorbic acid & different iron compounds

Sample	Mix 0	Mix 1	Mix 2	Mix 3	Mix 4
Ascorbic acid	100 ppm	100 ppm	100 ppm	100 ppm	100 ppm
Ferric sodium EDTA		40 ppm Fe			
Ferrous sulfate			60 ppm Fe		
Ferrous fumarate				60 ppm Fe	
Electrolytic iron					120 ppm Fe

- Dosage ascorbic acid: average amount
- Dosage iron: WHO recommendation
- 2 Storage conditions: 25°C / 50% r.H. (office Ahrensburg)
  30°C / 80% r.H. (climatic chamber)

Interactions - flour improvers & fortificants

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Mixes at the start of the trials

Interactions - flour improvers & fortificants

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Mixes after 4 hours @25°C / 50% r.H.

Interactions - flour improvers & fortificants

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Mixes after 24 hours @25°C / 50% r.H.

Interactions - flour improvers & fortificants

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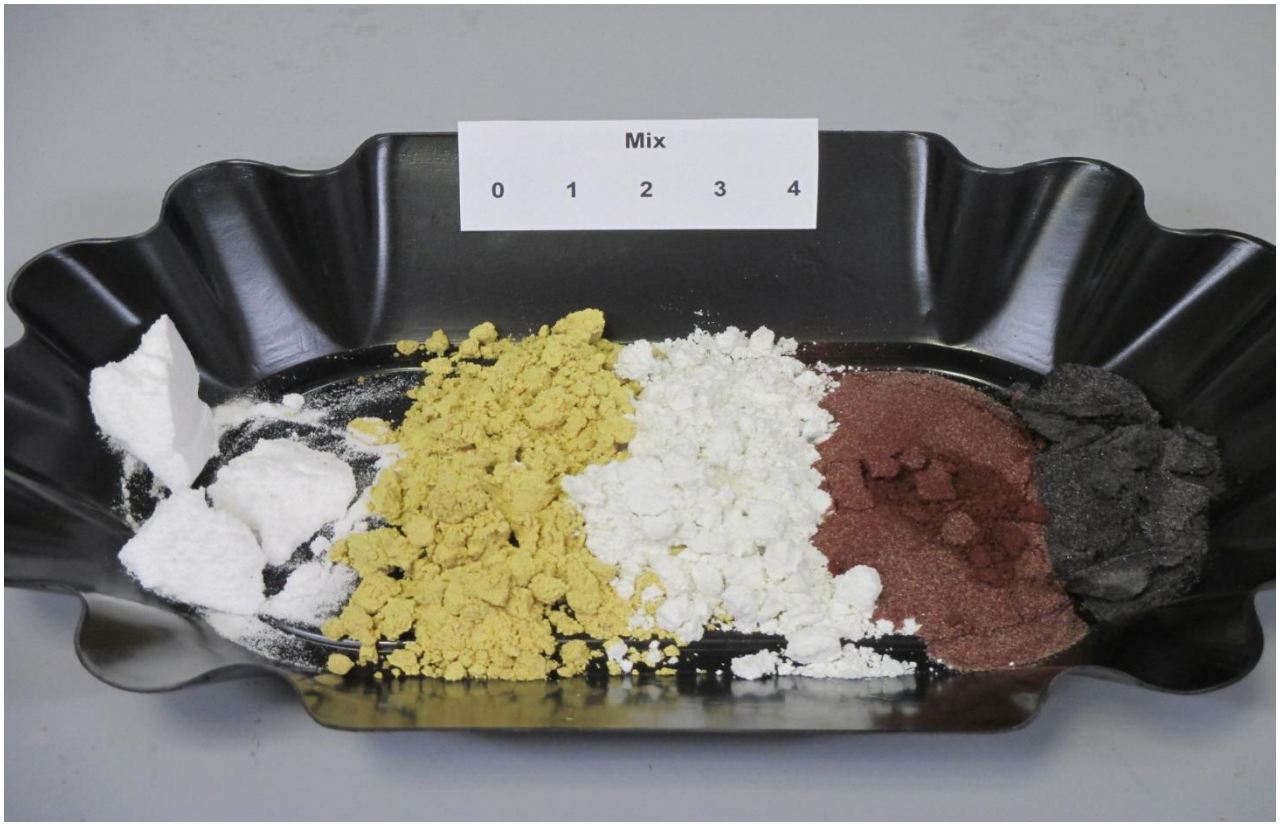
Mixes after 4 hours @30°C / 80% r.H.



Interactions - flour improvers & fortificants

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Mixes after 24 hours @30°C / 80% r.H.

Interactions - flour improvers & fortificants

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Ascorbic acid and iron – conclusion

- **Do NOT mix ascorbic acid and iron before adding to flour in hot and humid climates**
  - Ideally use two different feeders
  - Once in the flour => too diluted to interact

- **At moderate conditions it seems possible**
  - Ascorbic acid degradation should be analysed

Summary

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- **4 main iron sources are used in flour fortification**
  - Different properties with different bioavailabilities

- **Coarse Ferrous sulfate can lead to dark spots on bread crust**
  - Follow premix storage instructions

- **Iron sources can change the colour in cooked pasta and noodles**
  - Higher bioavailable compounds lead to bigger changes

- **Flour improvers should not be mixed with iron in concentrated form (before adding to flour)**
  - Once in flour the components are too diluted to interact

Summary

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IRON FORTIFICATION IS IMPORTANT

- **to fight iron deficiencies and related diseases**
- **Several studies prove the nutritional effectiveness**
- **Several studies investigated impact of iron fortification on food**
  - None to minor acceptable changes have been noticed
- **Trials should be initiated before flour fortification standard is established in a country**

Summary

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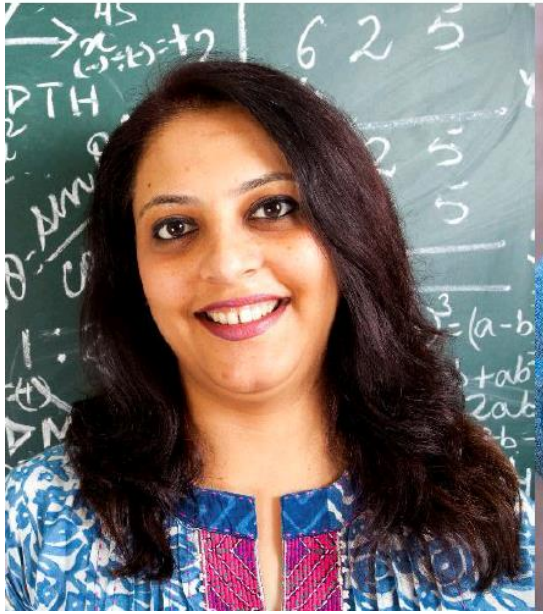
Source: Food Fortification Initiative (FFI)

Our Vision:

Smarter, stronger, healthier people worldwide by improving vitamin and mineral nutrition.



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Fortified flour – vitamins for a healthy life

Leader in flour applications.