FLOUR FORTIFICATION
MILLERS BEST/ENHANCED PRACTICES
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FLOUR FORTIFICATION INITIATIVE
Supported by THE MICRONUTRIENT INITIATIVE

INTRODUCTION
Wheat and maize flour fortification has been carried out in many countries for many years. At the first UN Summit on Children in 1992, vitamin and mineral deficiencies were identified as a significant public health problem in many countries.

One of the measures to address these deficiencies is staple food fortification. In particular, wheat and maize flour fortification has been identified as one of the best vehicles for the addition of a range of these vitamins and minerals often called micronutrients.

With assistance of UN agencies (UNICEF, World Food Program, World Health Organization), international non-government organizations (Helen Keller International, World Vision) and donors (Canadian International Development Agency, Global Alliance for Improved Nutrition, Micronutrient Initiative, United States Agency for International Development) many developing countries have implemented national flour fortification programmes. This has been achieved by working closely with the milling industry in each country.

This document has been developed for flour millers to meet the basic requirements to ensure the consistent fortification practices and to provide the requirements which can be defined as "best or enhanced practices." Achieving "best practices" requires companies to invest in these at their additional cost. This document is to be used as a complementary document based upon the existing information currently available.

Regulatory agencies in some countries may choose to make mandatory "best/enhanced practices" for their national milling industries to follow. However this may put an undue burden of added costs on the industry which may or may not be recovered through the pricing mechanism in the marketplace. For example, if the country has flour imports as well as locally produced flour, the imported flour may have been produced by mills following typical practices at a lower cost than "best/enhanced practices."
The decision to make "best/enhanced practices" mandatory must be made with the full involvement of industry and the government agency (or agencies) responsible for food control.

For more information, see www.sph.emory.edu/wheatflour

TOPICS COVERED

Quality Systems

Many quality systems are used in the food industry worldwide. One of the most important features that any quality system MUST have is documentation.
Without proper documentation of the procedures and processes involved in the production of food, these procedures cannot be audited and adjusted to changing methods of production. The following Quality Systems can be found in use in the milling industry world wide.

GMPs: A recognized set of *Good Manufacturing Practices*. GMPs can be dictated by government regulations or can be internally developed. In many cases GMPs are set out in a manual, printed or electronic format. They are in the form of Standard Operating Procedures (SOPs). SOPs are adopted for repetitive use when performing a specific action. GMPs include QA and QC procedures and testing.

ISO 9000 Series: An internationally recognized set of standards for qualification of global quality assurance and quality control standards. Adherence is accomplished through an application process for ISO 9000 certification in company standards for inspecting production processes, updating records, maintaining equipment, training employees and handling customer relations. The ISO 9000 – 2000 Series is more rigorous that the previous ISO Series.

HACCP: *Hazard Analysis and Critical Control Points* is a method used to ensure food safety by identifying potentially unsafe links in the food processing chain. HACCP systems are designed to identify the potential hazards that foods can be exposed to and to identify the control points required to prevent the manufacture and distribution of unsafe foods. The main categories of hazards are classified as Biological, Chemical and Physical Hazards.

The main feature of the HACCP system is that it can be developed for specific sectors in the food industry. In some countries HACCP systems have been made mandatory for certain types of foods such as meats, dairy products, seafood, and low acid food processing.

In addition HACCP systems are closed loop quality systems that lend themselves readily to process improvement through the identification of hazards and control points and procedure changes to eliminate them.

The minimum requirement for a flour mill is a set of documented GMPs.

PREMIX

Premix Specifications

Each mill is expected to have a set of premix specifications on file on the premises. The premix specifications must deliver the correct amount of micronutrients to meet the fortification regulations (preferably mandatory) at a specified addition rate measured in grams per MT of flour.

Premix Ordering

The mill should have a list of approved suppliers of premix. Relying on a single supplier can cause problems if the supply cannot meet an order and the milling company risks uncompetitive pricing with a single supplier. Ordering patterns should be based on flour production rates and the time it takes to receive premix from the supplier after an order is issued. In addition premixes have a limited shelf life, usually between 1-2 years (depending upon the composition and number of micronutrients) so the amount ordered should be calculated to ensure that the premix will not be left after its best before date is reached.

Packaging, storage and handling of premixes

Vitamin/mineral premixes should be packaged in air and watertight containers well protected from exposure to light. Typical packaging is a polyethylene bag inside a heavy, cardboard box. The package should be such that the bag can be easily resealed and the box closed after a portion of the product has been removed.

Premixes should be kept in their original containers in a cool dry place prior to use. Once opened exposure to the light and air should be minimized to prevent product degradation.

Handling of premixes at the mill

When handling the premixes the following precautions should be taken:

1. The operator should use a dust mask to prevent inadvertent inhalation of the active ingredients.
2. The operator should wash hands and skin areas exposed to the material during filling of the feeder hoppers.
3. The fortificant premix should be well identified to prevent accidental replacement with any other flour additive or premix (this can be achieved by using a color coded system which identifies the different additive feeders and additive boxes).
4. Opened boxes of premixes should be closed and stored away from light and heat.
5. Any spilled material must not be used and should be disposed of according to the supplier's instructions.
6. Premix **must** not be eaten.
7. Some allergic skin reactions may occur to vitamins and minerals used as flour fortificant such as niacin. It is therefore recommended that the operator use gloves and long sleeve shirts when handling the product. A common occurrence is skin reddening caused by the vasodilatation effect of niacin. This effect is transitory and not dangerous but it can be annoying.

Upon receipt of the shipment, the production lot number(s) should be recorded and retained. It is recommended that a first-in, first-out (FIFO) system of stock rotation be employed since the vitamins in the fortificant premix have a limited shelf life in terms of their biological effectiveness and stability. This is particularly the case with vitamin A. Unopened packages of premixes containing vitamin A may have a guaranteed (by the supplier) shelf life of six months in warm climates. In cooler climates the shelf life may be guaranteed (by the supplier) as long as 12 months. The shelf life of premixes containing minerals and only B vitamins is up to two years if unopened. Once a premix box has been opened it should be used within a few weeks.

Mill Preblends

Some mills may be required to dilute concentrated premixes prior to use by mixing with flour and other flour improvers. This will be due to relatively low production capacity of the flour mill or the degree of concentration of the premix or a combination of both. For example the premix may be supplied to mills that have an operating capacity of 150 MT per day but a few mills in a country may have a capacity of less than 60 MT per day. In this case the mill will dilute the premix 2 or 3 fold to ensure that the feed rate is adequate to ensure good dispersion in the flour fortification process.
This is usually done in a small mixer at the mill, making just enough preblend for one or two days production run time. It is not advisable to make more than that since the flour-nutrient blend will have a reduced shelf life.

Example of preblend formulation.
Premix Dosage rate, according to suppliers specification: 200 grams per MT
Dilution Formula
The following table shows a dilution formula for a Mill PreBlend:

Component	**Weight kg**	**%**
Premix as supplied	3.333	33
White flour (low extraction)	6.667	66
Total	**10kg**	**100**

Mill Preblend dosage rate: 600 grams per MT of flour

Mill Preblends with other ingredients
Flour improvers may be included in the blend, including enzymes, azodicarbonamide and ascorbic acid.

Caution:
Additives that should **never** be included in this blend are concentrated forms of potassium bromate and benzoyl peroxide (flour bleach). They are strong oxidizers that have been known to adversely react with fortificants.

FEEDERS (DOSIFIERS)

Feeders control the amount of premix or fortificant added to flour by three general principles:

- Volumetric addition is based on the principle that the **volume** of the material being added has a set weight when handled in a uniform manner. Volumetric addition is similar to using a cup or spoon to measure out ingredients in home baking. The same simple procedure can be used to fortify flour in small batch mixing processes. The most commonly used method to fortify flour at the mill is with volumetric feeders that dispense a set volume of a premix at a constant rate. The weight of the premix dispensed depends on its bulk density. Iron sources have higher bulk densities than vitamins and flour. The higher the density, the greater weight of material that is dispensed at the same feeder setting. The minimum error of measurement for volumetric addition is ±2%.

- Gravimetric addition involves measuring the **weight** of material to be added on a continuous basis. Weigh belt feeders are used in continuous systems that can give direct weightings of the material being dispensed, but they usually require a greater volume of material than used in most fortification operations. They could also be used in calcium fortification. Typical costs for weigh belt feeders are $5,000-$10,000

- Loss of weight addition is based on taking continuous readings of the weight of the premix and feeding equipment. This is achieved by mounting the feeder on *load cells* that send out an electronic signal proportional to the total weight of the feeder and the premix in the hopper. The rate at which this weight drops with time indicates the true addition rate. This system is somewhat more complex and expensive than is required in most cereal milling operations. When a new mill is being constructed the use of loss-in-weight feeders is recommended as the incremental cost is very small compared to the overall cost of the new mill.

Types of Powder Feeders and Designs

Many different types of powder feeders are available, ranging in degree of sophistication from complex to simple. Feeders also differ in how easy they are to clean, repair and maintain. Three types of powder feeder mechanisms are used in flour mills today: screw type, revolving disk, and drum type. These differ in the mechanism used to deliver a constant rate of powder (see diagrams). Most of the newer feeders manufactured today are of the screw type.

Screw feeder

The screw type feeder is powered by a variable speed DC electric motor, which is used to control the feed rate of the powder. The shape of the feed screw determines the feed rate capacity. Large capacity feeders may use a gearbox to increase and adjust the feed rate capacity. The premix is kept flowing by means of a large conditioning screw or flexible pulsating plates on the bottom of the hopper. Large hoppers may also use an intermittently run vibrator to prevent bridging. A low-level detector can be installed on the bottom of the hopper to indicate when the premix is close to running out. The on/off switch, speed control and low- level indicator light can be located near the feeder or at a remote location.

Advantages of this type of feeder are that it sustains a constant addition rate, has a wider range of delivery rates and hopper capacity, uses fewer mechanical parts and is less expensive to build. They can be more sanitary and easier to maintain than the other types of feeders. They are the main type of feeders available as new equipment.

Revolving disk feeder

This older type of feeder uses a revolving disk equipped with a slide mechanism to control the rate of powder discharge. The disk revolves at a constant speed and can be run with either an AC or DC motor. The size of the hopper is usually smaller than the hoppers of other types of feeders requiring that it be refilled more frequently. This can be a disadvantage for larger flour mills since refilling takes up more of the miller's time. This type of feeder uses more mechanical components than the screw feeder.

Drum or roll type feeders

This type of feeder has been a workhorse for use in flour treatment, with many thousands of units still in use. It operates by allowing the powder to pass between two revolving cylinders, as shown in the diagram. Either a DC or AC motor can power the drum and a gearbox and a pulley system control the rotation speed. Pulleys and wheels of differing diameters can be used to make gross adjustments in the feed rate capacity. An adjustable gate makes fine adjustments in the rate of feed. This design requires more parts to operate and has higher maintenance requirements. Shear pins in the drive mechanism cause the feeder to stop working if large objects (bolts, plastic) get stuck between the rolls.

Feeder calibration and maintenance

Calibration

Most flour mills fortify flour continuously using an ingredient feeder or dosifier to meter the premix into the flour as it flows through the mill. The alternative is to use a batch mixing system where a set quantity of the premix is weighed out and blended into a set quantity of flour. In continuous systems the fortification feeder must be adjusted to add the correct amount of premix based on the *flour flow rate* and the addition rate specified for that premix. Mills have to know, or determine, the flour flow rate, typically in Metric Tons per hour, kg/min or some similar unit, in order to make this calculation.

The premix addition rate should be checked routinely as part of the normal quality control practices. This can be done by running a "feed rate check" on the feeder, and changed according to any change in the flour flow rate. This is done simply by putting a plate or cup under the discharge spout of the feeder for 60 seconds and weighting the amount of premix collected to an accuracy of 0.1 grams. A standard lab balance or electronic scale can be employed for this purpose.

Maintenance
Feeders require routine maintenance to assure consistent performance. This includes routine lubrication, replacement of worn parts and materials. The recommended maintenance schedule should be provided by the supplier.
Note: The feeder may require recalibration following maintenance before it is put back into service.

FORTIFICATION PROCESS

Addition and Mixing Design Delivery Systems
Once the feeder has delivered its required quantity there are two ways that the material can be introduced into the flour stream.

Pneumatic conveying

The first is by pneumatic conveying. The premix drops into a venturi tube, which injects the premix into the air stream. The material is blown by positive pressure or sucked by a vacuum through a pipe into the flour collection conveyor. If that is not possible, some downstream location in the flour flow can be utilized allowing that some flour mixing is provided.

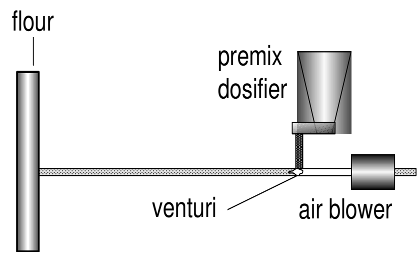
Gravity feed

The second method of delivery is by gravity feed, where the feeder is placed above a conveyor. The premix is dropped directly into the flour as it flows through the conveyor, often the *flour collection conveyor*. This conveyor is designed to collect and blend the individual flour streams coming from the sifting equipment so that the final flour is uniform. The location where the flour fortificant is introduced to the flour conveyor is critical. It should be located in the front half of the collection conveyor above the blades of the mixing screw. If located too close to the discharge end the fortificant may not have enough time in the conveyor to be blended properly with the flour.

Location of Powder Feeders
Feeders should be placed in a dry location and preferably away from sunlight. This will prevent the components from any potential interaction with sunlight. Vitamin A, riboflavin and folic acid are sensitive to light and atmospheric oxygen. Ideally, feeders should be placed in an area of the mill easily accessible to the operators and handy to the miller's office or flour testing station. Keep a few boxes of the premix adjacent to the feeders.

Pneumatic method

Pneumatic Method of Premix Delivery

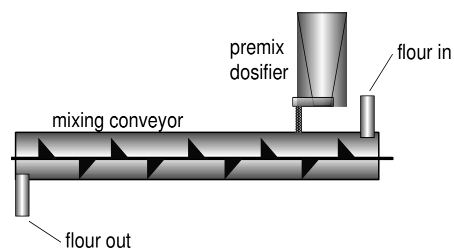


Pneumatic conveying of flour fortificants from the feeder to the flour collection conveyor has one key advantage. It permits the feeder to be located anywhere in the mill, allowing it to be conveniently located or added to a mill retroactively. However a pneumatic conveying system requires the investment of additional equipment such as blower, valve and piping. The pipes used to convey the material should have as few as possible a number of sharp bends and twists to prevent the possibility of clumping and blocking of the pipes by the flour fortificant. The venturi tube should be checked occasionally to see if there is any build up of the premix, and be cleaned if there is. Pneumatic conveying of flour does not provide much mixing of the premix into the flour, so it should lead to a mixing conveyor or sieve rather than directly into a flour holding bin.

Gravity feed system

The gravity feed method requires the feeders to be located on top or above the flour collection conveyor. The material falls directly from the discharge end of the feeder into the flour stream. New mills are ideally suited to the installation of gravity feed locations, whereas older mills may be configured in a way that prevents the installation of this type of system. The equipment requirements of a gravity system are less than those for pneumatic conveying systems.

Gravity Feed Method of Premix Delivery



The feeder can sit either directly on top of a flour collection conveyor or on a platform or on the floor directly above it with the discharge spout feeding into a mostly vertically tube dropping down to the collection conveyor. The premix must enter the flour stream at least 3 meters from discharge end of the flour collection conveyor to ensure adequate blending. The collection conveyor may be well above the floor. This requires construction of a platform from which the hopper can be filled. If necessary because of space restrictions, feeders can be installed on the floor above and the premix dropped to the conveyor through a spout.

In some cases the feeder may be connected to the flour discharge spout of a plansifter. The sifter flour spout must have a significant amount of flour entering into the flour collection conveyor on the floor below. The sifter flour spout must enter the flour stream at least 3 meters from discharge end of the flour collection conveyor to ensure adequate blending.

The three- meter distance requirement may be lifted in some mills where the flour is pneumatically blown from the collection conveyor to either a packing bin or flour storage bin, or where the flour collection conveyor discharges into another conveyor and the total length of the mixing distance after the premix is added is at least 3 meters.

Electrical interlock system

It is highly recommended that an electrical interlock system be installed between the feeder motor and the motor driving either the flour collection conveyor or the first break plansifter. An interlock causes the feeder to stop if the flour collection conveyor or plansifter stops. The interlock system can be installed directly into the mill control panel. This interlock system will prevent the inadvertent over-treatment of the flour, if there is a mechanical breakdown in the mill. In pneumatic delivery systems an interlock should be made between the feeder and the blower to insure that the feeder cannot be turned on without the blower operating. This will prevent buildup of the premix in the pneumatic lines followed by over-treatment of flour once the blower is turned on. An alternative approach is to have an automatic shut off switch on the feeder that is hooked up to a flour flow indicator or a pressure indicator in a pneumatic system.

Continuous monitoring system

Most mills are designed to have a constant flow of flour, but "*chokes*" or blockages may interrupt flow. Over-treatment of a portion of flour can occur if the flour stops or slows down but the feeders keep operating at the same rate. This can be corrected automatically by having the speed of the feeder slaved to the flour flow through the use of an electronic controller. This requires equipment that continuously monitors the rate of flour flow and generates an electronic signal proportional to that flow rate. This signal is then used to control the motor speed of the feeder.

Additional mixing conveyor

Most mills do not have automated control capabilities and must adjust the feeders manually as described in the following section. Some of the small, older mills do not have a point in the system with a known, constant flow of flour, which makes continuous fortification difficult to achieve. One solution to this is to install a mixing conveyor running from a flour holding bin to the packout bin. The feeder would drop or blow the premix into the start of the special conveyor.

Batch blending system

Some small mills may choose to use a batch blending system with or without a feeder installed. These systems use a large capacity mixer ranging from 1 to 5 MT and either feeder or to add the premix or a known weight of premix.

The following table shows a typical formulation that may be used, assuming a premix with specified dosage 200 grams per MT.

Component	Weight kg	50 kg Bags
Flour	1000	20
Premix	0.2	

The blending time will need to be determined using an experimental design that uses mixing times, sampling in at least 6 different locations in the mixer (top, middle and bottom) and quantitative analysis using iron as the marker (if iron is in the premix)

Low level indicator
A low level indicator should be installed in the feeder hopper so that an alarm will sound to inform the millers that the premix needs to be added to the hopper to prevent the production of unfortified flour.

Instructions for Fortification Operations
The following step-by-step procedures should be followed in setting up and calibrating feeders.

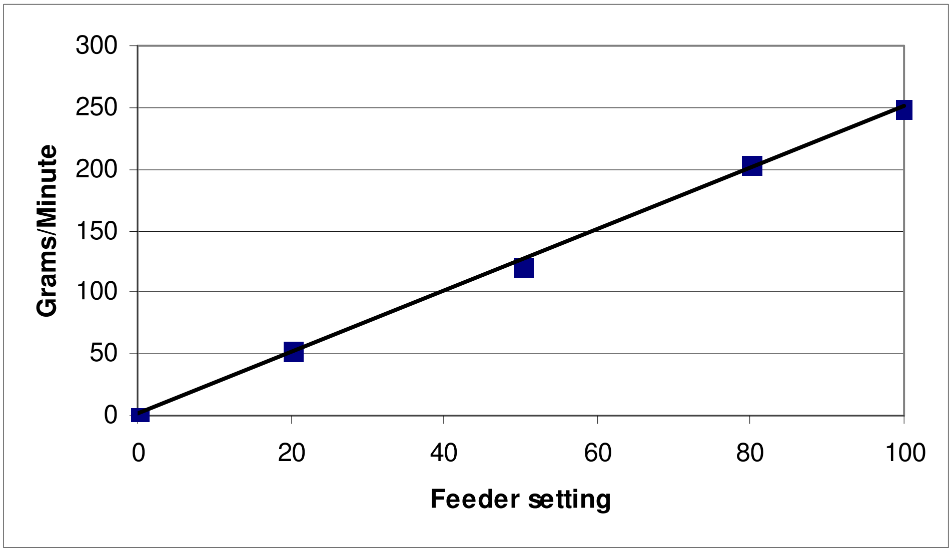
Feeder set up

1. Locate and install the feeder based on optimal mill equipment configuration. Note position requirement on flour collection conveyors for gravity feeder set up. Insure there is adequate mixing of flour after point of premix addition.
2. Install voltage regulator if there is a large variation in electrical voltage (over ± 20%).
3. Install the electrical interlock system either directly to flour collection conveyor motor or mill control panel.
4. Install the low level indicator.
5. Check to see that light indicating low premix level in hopper is operating.

Feeder calibration

1. Fill hopper about half full with premix to be added.
2. Set feeder to maximum discharge.
3. Run feeder for 2 minutes.
4. Weigh premix.
5. Calculate maximum discharge per minute.
6. Optional: repeat above with different speed or percent settings.
7. Using graph paper or spreadsheet program, prepare a chart (see following figure for example) showing feed discharge rate per minute for different feeder speed settings from 0 to 100% of maximum discharge.

Example of feeder calibration curve



Flour Production Rate Determination

The Flour Production rate needs to be determined at the point of the fortification process. This can be done by taking measurements from the wheat flour production scale. In some cases flour mills pack the flour on line as it is being milled. In this case the flour production can be determined by counting the number of bags packed per hour.

Premix Feed Rate Determination

Use this to determine the feed rate of premix in grams per minute required to fortify the flour at the recommended level.

1. Determine the recommended addition rate of premix (from supplier specifications).
2. Calculate premix feed rate per minute using formula:
   Premix Weight in grams per ton divided by 1000 = grams per kg flour

   Premix Weight per kg multiplied by production rate per minute in kg = Premix Weight required per minute.

3. Adjust the control/dial on feeder to deliver weight of premix per minute.

Note: If the mill is using diluted preblend then the feed rate must be determined based on the dilution rate of the preblend.

Fortification Operation

1. Start mill up and let it run until the mill has reached its expected production rate.
2. Start feeder at required setting.
3. Ensure feeder hopper contains premix.
4. Conduct check weighing (see following procedure) at start, middle and end of mill production shift to verify correct addition. Adjust if addition rate is above or below target. Recheck addition rate using check weigh procedure.

5. Visually check feeder during production run to ensure sufficient premix in hopper and that feeder is operating properly.
6. At end of production run turn off feeder before shutting down mill.
7. Maintain production records showing:
    a. Lot number of premix used
    b. Check weights
    c. Time of check weighing
    d. Times of production run start and finish

Mill Quality Control

The standard procedure utilized by large flour mills to insure that flour is properly fortified includes:

Use of a quality feeder whose delivery of premix can be tied into the flow rate of the flour and which will stop when the flour flow stops.

Regular checking of feed rates on feeder at start, middle and end of each production shift.

Regular iron spot tests on flour at start, middle and end of each production shift or according to the current quality control sampling schedule. In addition iron spot tests should be carried out on packing and shipment samples.

In the case of premixes containing NaFeEDTA the test developed by Chinese CDC or Akzo-Nobel should be used.

Checking of premix usage against production of flour that should have been fortified. This typically should be done on a weekly or monthly basis.

Optional quantitative testing of iron on a weekly or monthly basis. In the case of premixes containing NaFeEDTA the test developed by Chinese CDC or Akzo-Nobel should be used. An outside lab is recommended to be used.

Optional quantitative testing of all fortification components in a composite sample on a monthly or quarterly basis. This must be done by an outside lab. Some premix companies offer this service to their customers at no charge.

Record keeping

Good record keeping is the key to mill QA/QC in flour fortification. Each mill should have a written plan of what records they want kept, how the data is to be entered, who should collect them and where they are to be kept. Records of all of the above activities should be kept by the mill and made available to government or flour customer inspection or audits when requested.

Analytical testing

Flour samples should be tested to verify that it has been properly fortified. Three types of testing are possible:

- **Qualitative tests** show simply the presence or absence of an added micronutrient. An example is the black light (UV light) test for riboflavin. This type of test is used to see if the flour has been fortified or not.
- **Semi-quantitative tests** give a rough indication of the level of an added nutrient. Examples are the iron spot test and a color test recently developed for vitamin A in flour. This type of test tells whether the level added is low, normal or high.
- **Quantitative assay tests** give an actual value for the level of micronutrient in the sample. Unlike the other two types, which respond to added micronutrients,

quantitative tests generally measure total content or both the natural and added levels, but some test methods have been developed to show only the added.

Sampling

The way flour samples are obtained and handled is an important component of the analytical procedure, particularly when submitted for quantitative testing, and should be well documented in the QA plan. The best place to sample is at or directly prior to packing, since this represents the final mill product. Composite samples are preferred to spot samples for quantitative testing, but spot samples are acceptable for the iron spot test.

A good composite sample will have 7 spot samples taken over an 8 hour period. One example is to place 50 gram spot samples into an opaque container holding at least 700 grams of flour. When all 7 samples are collected the composite is mixed by inverting and shaking the container. A single sample is then taken for testing. It is always good practice to retain all or part of the original sample in case something goes wrong with the other sample. A minimum composite sample consists of 3 spot samples taken over an 8 hour period.

Samples of fortified flour or meal must not be exposed to direct sunlight or strong indoor lighting to prevent degradation of light sensitive vitamins such as Vitamin A and Riboflavin (vitamin B_2). They should be well labeled with the name of the mill, date, type of flour and whether or not they are fortified (unfortified samples are often collected to establish base line natural levels). If regular samples are to be collected, it is also a good idea to number them consecutively. This sample data should be entered into a mill sample record book. Taking and testing samples is pointless unless they are well documented.

When a mill first starts fortification they may want to have a number of spot samples of fortified product tested along with some unfortified samples to gain a better picture of their capacity to fortify correctly along with the level and variation they can expect. For example, they may take a spot sample every 6 hours over a 3 day period and have them tested for iron as the indicator nutrient. They may also want to take a couple composite samples and have those tested for all the added micronutrients.

Once fortification has commenced, it is not practical to run that many samples on a regular basis. Medium and small size mills may wish to send in a composite sample a couple times a year, large mills may want to do it every month or quarter, while very large mills may wish to do that more often. Such samples are generally tested for all added micronutrients but testing one or two indicator nutrients may be sufficient.

When an official inspector is collecting samples it is recommended that the sample taken be separated into three separate samples, one for the test; one for the mill and a third one in case the other two do not agree to their results.

Iron spot test

The iron spot test (AACC method 40-40, Iron- Qualitative Method) is universally used by millers to check whether flour has been properly fortified. This is a simple, inexpensive, semi-quantitative procedure that should be run on fortified flour on a regular basis, typically every 2 or 4 hours for a large mill. It should be run at least once every eight hour shift at a minimum for flour sampled during production. It may also be run on flour sampled in the warehouse to verify it has been properly labeled as being fortified.

The test will indicate whether the flour is under-fortified or over-fortified to a sufficient degree for the mill to take corrective action. The iron spot test can also indicate whether the iron being added is reduced, elemental iron, or a salt (ferrous sulfate or ferrous fumarate), in case the mill is adding both types. While this test is only for iron, it can be assumed that if the iron is correct, the other added micronutrients (i.e. folic acid) will be correct as well since they are added as a single premix.

Quantitative testing

While much can be accomplished through simple record keeping, feed rate checks and iron spot tests, there are times when it will be useful to do quantitative assays of the micronutrients in flour. Quantitative analytical procedures are available for all the micronutrients that might be added to flour. These differ greatly in complexity, analytical error (CV), type of equipment and skill needed to run them, as well as cost.

It is strongly recommended that quantitative tests on flour not be run by the flour mill. Rather they should be run by an outside laboratory that is familiar with the methodology and can run the test on a regular basis. The reasons for this are:

- The cost of the equipment and trained personnel needed to run many of these tests are beyond the resources of most milling companies.
- These tests need to be run on a regular basis if accurate results are to be obtained. Mills would only run these on an occasional basis and would never become very skilled in them.
- Mills would not save money by running these tests themselves over sending them out to an outside lab, particularly if they can have it done at no charge by their premix supplier.
- Flour mills in countries that have been fortifying flour for many decades, such as those in the United States and Canada, do not run these tests themselves, which shows that internal testing is not necessary for a successful QA/QC program.
- Quantitative results are normally used to show to a customer or government inspector that a product has been correctly fortified. Results from an outside laboratory have greater credibility than those produced internally.
- Suitable outside testing facilities are generally available for most countries.

MONITORING PREMIX USE AND INVENTORY CONTROL

One of the key tools for fortification is a premix usage and inventory control system. This tool is designed to be used to verify that premix is being added at correct levels and is meeting the target addition rate within a specified range.

Record Keeping And Usage Reconciliation Calculations

All good quality assurance systems require the use of proper documentation and the maintenance of good records. This allows the system to be audited to ensure that the flour fortification process is being carried out consistently.

The following table is designed to be used in flour fortification programmes at the mill level to measure the inventory of premix on a regular basis and to determine how closely the actual addition rate is to the target rate. The target rate is defined by the recommended addition rate of premix in grams per MT of flour. This recommended rate is provided by the premix supplier.

FORTIFICATION PREMIX CONTROL RECORDS

FORTIFICATION PREMIX

A STARTING INVENTORY	____ KG
B AMOUNT PURCHASED	____ KG
C ENDING INVENTORY	____ KG
D AMOUNT USED (A+B-C)	____ KG
E PRODUCTION OF FORTIFIED FLOUR	____ MT
F ADDITION RATE (D*1000/E)	____ G/MT
G TARGET ADDITION RATE	____ G/MT
H PERCENT OF TARGET (100*F/G)	____ %

The frequency of this inventory control system can be carried out daily, weekly or monthly. At the start of a flour fortification programme this method can be used daily until the system can be demonstrated to show that it the process is consistent.

BASIC AND BEST/ENHANCED FORTIFICATION PRACTICES

The following table is designed to be used to determine what are the Basic and Best/Enhanced Practices for fortification at the flour mill level. In addition indicators are provided to allow for millers to conduct self assessments and for auditing purposes.

Fortification Component	**Basic Practice**	**Indicator**	**Best/Enhanced Practice**	**Indicator**
Quality System	GMPs	GMP Manual	HACCP and or ISO 9001 or 9002	Manuals Third Party Audits Certificates
Premix				
Premix Specifications	On file in GMPs	Documents	Quality System Manuals	Documents
Premix Ordering	SOPs	Documents	Quality System Manuals	Documents
Packaging, storage & handling	SOPs, Dry, out of sunlight, boxes closed, Premix Lot numbers recorded	Inspection documents	SOPs, Dry, out of sunlight, boxes closed, Premix lot number recorded	Inspection documents
Handling Practices	SOPs, feeder hoppers covered, employee protection masks and gloves	Inspection	SOPs, feeder hoppers covered, employee protection masks and gloves	Inspection
Mill preblends	SOPs, production records	Inspection documents	SOPs, production records	Inspection documents
Feeders				
Type	Volumetric, screw, disk or drum	Inspection	Gravimetric, loss in weight	Inspection
Feeder Calibration	SOPs	Documents	SOPs	Documents
Feeder Maintenance	SOPs	Documents	SOPs	Documents

Fortification Process				
Feeder Location or addition point	At least 3 metres from discharge of flour collection conveyor OR additional blending system, pneumatic or conveyor	Inspection	At least 3 metres from discharge of flour collection conveyor OR additional blending system, pneumatic or conveyor	Inspection
Feeder Control	Electrical Interlock System	Inspection	Electrical Interlock System	Inspection
Continuous monitoring			Feeder controls tied in with flour scale and computer or microprocessor controlled	Inspection
Production Rate Determination	SOPs Calculations	Inspection and documents	SOPs Calculations	Inspection and documents
Premix Feed Rate Determination	SOPs Calculations	Inspection and documents	SOPs Calculations	Inspection and documents
Routine Check weighing	SOPs, Feeder discharge check weighing Every 8 hours or once per shift by miller	documents	SOPs, Feeder discharge check weighing Every 4 hours or once per shift by miller	documents
Mill QC				
Sampling Schedule	SOPs, Iron Spot test every 4 hours	QC records documents	SOPs Spot test every 2 hours	QC records documents
Analytical Testing Qualitative	SOPs, QC Methods Iron Spot test	QC records documents	SOPs, QC Methods Iron Spot test compared to standard sample	QC records documents

Analytical Testing Quantitative	Composite samples, monthly basis using external lab – Iron only	QC records documents	Composite samples, monthly basis using external lab – All added micronutrients	QC records documents
Usage & Inventory Control	SOPs, Calculations on Monthly basis	QC records documents	SOPs, Calculations on weekly basis	QC Records documents

REFERENCES

Fortification Handbook Vitamin and Mineral Fortification Of Wheat Flour And Maize Meal, The Micronutrient Initiative 2005

The Miller's Fortification Tool Kit, CD ROM, Iron Deficiency Project Advisory Service and The Micronutrient Initiative 2005

The Regulatory Monitoring Of Fortified Wheat Flour, a Manual For Millers & Food Control Agencies, DRAFT, PAHO

Guidelines on Fortification of Foods with Micronutrients, WHO/FAO 2007