

Fortify wheat flour with iron and folic acid targeting to pregnant women and child nutrition: At Africa Private Limited Company



By Zewditu Yiheis Habtu

A Thesis Submitted to the department of chemical engineering

School of mechanical, chemical and materials engineering

Presented in Partial Fulfillment of the Requirement for the Degree of
Master in chemical engineering

Office of Graduate Studies

Adama Science and Technology University

October, 2023

Adama, Ethiopia

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DECLARATION

I hereby declare that this Master thesis entitled “Fortify wheat flour with iron and folic acid targeting to pregnant women and child nutrition: At Africa Private Limited Company” is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

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Name of student

Signature

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Date

,

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled “Fortify wheat flour with iron and folic acid targeting to pregnant women and child nutrition: At Africa Private Limited Company” prepared under my guidance by Zewditu Yiheis Habtu submitted in partial fulfillment of the requirements for the degree of Master of Science in chemical engineering. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Melaku Tesfay (PhD)

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date

APPROVAL

I, the advisor of the thesis entitled “Fortify wheat flour with iron and folic acid targeting to pregnant women and child nutrition: At Africa Private Limited Company” and developed by Zewditu Yiheis Habtu, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Zewditu Yiheis Habtu have read and evaluated the thesis entitled “Fortify wheat flour with iron and folic acid targeting to pregnant women and child nutrition: A case study of Africa private limited company” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in chemical engineering.

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LIST OF ACRONYMS AND ABBREVIATIONS

ID	Iron deficiency
IDA	Iron deficiency anemia
FIFO	Fist in fist out
WHO	World health organization
IFA	Iron and folic acid
ISO	International organization for standardization
ES	Ethiopian standard
FeEDTA	Ferric ethylene diamine tetra acetic acid
NaFaEDTA	Sodium Ferric ethylene diamine tetra acetic acid
AOAC	Association of official analytical
FFI	flour fortification initiative
NGO	Non-governmental organization
MT	metric ton
DALY	Disability adjusted life year
NTD	Neural tube birth
COA	Certificate of analysis
PLC	Privet limited company
HLW	hectoliter weight
UV	Ultra violet

ABSTRACT

A food fortification refers to the addition of micronutrients to processed foods. Wheat was one of the most widely produced cereal crops in the world and most was destined for human consumption. Wheat is good sources of vitamin, iron and zinc.

Fortification of wheat flour by iron and folic acid was important micronutrients for physiological, functional, growth and development as well as maintenance of life for the mother and her fetus during pregnancy and in later life. Specific mixing of flour with iron and folic acid were subjected to fortification process with the objective of enriching the protein and mineral content of flour and produce a range of fortified flour. The proportion of flour and iron - folic acid addition using uv method. The iron addition was maintained at different ratio 35mg, 40mg,45mg,50mg,,55mg or the folic acid was maintained at different ratio 0.45mg,0.5mg,0.54mg,0.54mg and 0.58mg on the physical properties of fortified flour. A distinct absorption wavelength was selected for folic acid and iron in distilled water. Of the two wavelengths where maximum absorption was observed for folic acid, 310 nm and iron for 278nm was selected as being selective for folic acid and iron in the presence of distilled water. The recovery was 12.74g/l and 8.18mg/ml for folic acid and iron in fortified bread respectively.

Folic acid fortification has significantly reduced the prevalence of neural tube defect. Iron fortified food have the potential to positively affect hematologic outcomes of women and children, including the levels of hemoglobin and serum ferritin, and the risk of anemia and iron deficiency.

Keywords wheat flour, iron, folic acid

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Food fortification was the mechanisms of adding any external essential nutrient or any other ingredient to a food commodity that may or may not already contain that nutrient or ingredient for the purpose of improving, correcting, and/or preventing any revealed deficiency of one or more nutrients in any food. matter (victore R.Preedy Ronald Ross watson).

Fortification of wheat flour by iron and folic acid was important micronutrients for physiological, functional, growth and development as well as maintenance of life for the mother and her fetus during pregnancy and in later life. In Ethiopia, iron and folic acid supplementation was the main strategy to prevent material death due to anemia and adverse birth outcome matter (victore R.Preedy Ronald Ross watson).

International organizations have advocated routine iron and folic acid supplementation for every adolescent and adult pregnant woman. While iron supplementation with or without folic acid has been used in a variety of doses and regimens, current recommendations for pregnant women include the provision of a standard daily dose of 30–60 mg of elemental iron and 400 mg of folic acid to reduce the risk of anemia and low birth weight, starting as soon as possible after gestation begins and continuing for the rest of the pregnancy.

The iron and folic acid are usually added at a dosage of 100-200g/t through a gravimetric feeder. a gravity driven system is the best site for adding iron and folic acid before the mid-point; along the screw conveyor that collects flour from the mill passages and just before the bulk storage or sacking. (www.nutrition.improvement.com)

The stability of the iron and folic acid in the carrier is considered one of the key factors toward the success of any fortification program, as fortified flours might undergo physicochemical changes during storage and processing. Exposure of the fortificants to any of the physical and chemical factors including heat, moisture, air, or light and acid or alkaline environments during food processing, packaging, distribution or storage affects its stability. Factor affecting the choice of the forms of iron to use include bioavailability, functional and stability properties, commercial availability of food grade materials and cost. Unfortunately the forms that show the greatest functional stability are often less

absorbable while those forms that show the greatest bioavailability had greatest potential for damaging product quality. (Mehansho & Manner,1999).

The ultimate goal of this work is to develop fortified bread from a mixing of iron and folic acid with wheat flour using gravity feed. Additionally, the study describes changes in the physicochemical properties of the product with moisture content of feed, and screw speed and functional properties of the products sensory as well as textural analysis.

1.2 Statement of the problem

There are several wonderful fortification of wheat flour by different amount of vitamin and minerals. The micronutrient employed in manufacturing operations is extremely expensive. One of the best and most efficient ways to fortification of wheat flour by adding iron and folic acid. Iron and folic acid mixing to flour s easy and easily knowing what amount of iron and folic acid adding to the flour by iron spot test.

Deficiency of iron that effect pregnant women and her child and deficiency of folic acid it nuraltube defect. Therefore to solve this problem adding iron and folic acid to wheat flour is crucial. Fortification of wheat flour with iron and folic acid is highly important to pregnant women and her child.in this study fortification of wheat flour with iron and folic acid by the method of uv analysis.

1.3 Objectives of the study

1.3.1 General objective

To fortify wheat flour with Iron and folic acid targeting to pregnant Women and Child Nutrition case of Africa flour factory.

1.3.2 Specific objectives

- To develop and characterize iron fortified wheat flour
- To develop and characterize folic acid fortified wheat flour
- Study the effect of processing on the sensory qualities of the fortified product
- Study the effect of post processing conditions on the end use

1.4 Significance of the Study

This study will introduce the application of fortified flour for pregnant women and her child. Generally, once the research is done successfully and implemented, it is expected to:

- ❖ Decrease the effect of anemia and neural tube defect.
- ❖ It can serve as a baseline data for subsequent studies in the field.
- ❖ It gives hints for the researchers, who will have a plan to mixing iron and folic acid to wheat flour.
- ❖ Introduce alternative fortification of wheat flour by iron and folic acid

1.5 limitation of the study

The following are a few limitations of the fortified wheat flour; consuming fortified foods with unprocessed food may increase the risk of nutrient overdose. Eating only fortified food and ignoring fruits and vegetables can cause low nutrition.

Iron fortification of wheat flour is water-insoluble, and that it has a lower relative bioavailability than other major iron fortification compound.

Supplementing with too much fortified flour with folic acid while pregnant may increase insulin resistance and slow brain development in children.

When taken by mouth: it is likely safe for most people to take folic acid in doses of no more than 1mg daily. Doses higher than 1mg daily may be unsafe. These doses might cause stomach upset, nausea, diarrhea, irritability, confusion, behavior changes, skin reactions, seizures, and other side effects.

The micro dozer needs daily cleaning and iron and folic acid easily poisoned by un safe place.

CHAPTER TWO

LITERATURE REVIEW

2.1 Fortification process

Fortification was the process of adding vitamins and/or minerals to foods to increase its overall nutritional content. Fortification when imposed on existing food patterns might not necessitate changes in the customary diet of the population and does not call for individual compliance. It could often be dovetailed into existing food production and distribution systems. For these reasons, fortification could often be implemented and be sustained over a long period of time, making it to be the most cost-effective way to overcome micronutrient malnutrition (Kaishozi, n.d.).

Cereals were important food vehicles for fortification. Though several foods could be used for carrying micronutrients, wheat flour was excellent vehicle because they were staple foods in many parts of the world and key ingredient in so many food preparations. When micronutrient deficiencies were population-wide and result from a combination of low intake and/or low bioavailability, fortification of commonly consumed cereal flours with iron, folic acid and other vitamins offers a number of strategic advantages. (Kaishozi, n.d.).

2.2 Grain Structure and Cereal Composition

All cereal grains consist of three main components. These were bran, endosperm and germ (Johnson et al., 2004). The bran consists of several layers of fibrous material that surround the endosperm and protect the germ component. These layers were known as the pericarp, test and aleurone. The outer bran layers were rich in dietary fiber and have high levels of minerals. The aleurone layer contains high levels of vitamins and phytic acid. The endosperm contains starch and protein. The protein present in the endosperm in wheat becomes the gluten matrix with the addition of water. This matrix provides the structure for breads, cookies, biscuits, noodles and other processed foods made from wheat flour. Wheat was the only plant that has this gluten forming protein. The germ component was the embryo of the plant. It is high in protein and fat. In addition, the germ contains the highest level of group B vitamins.

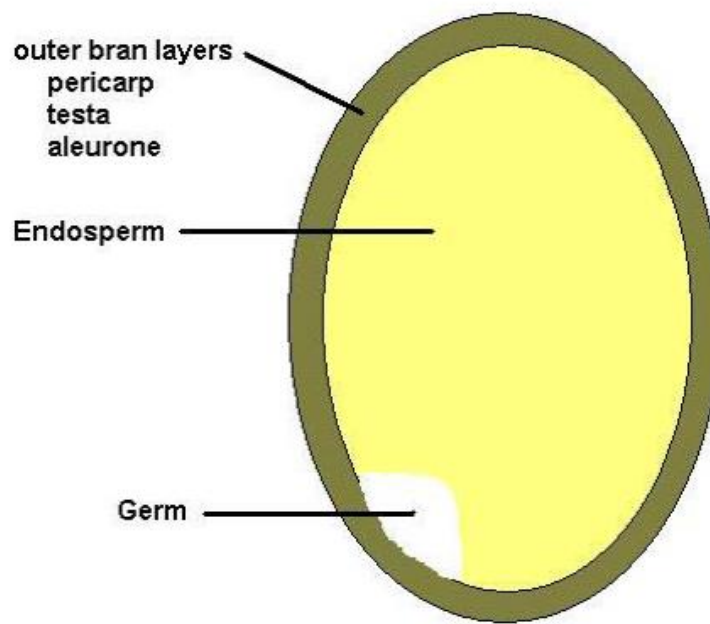


Figure 2.1: Stylized Grain Structure Diagram (Johnson et al., 2004)

2.3 General requirement

Fortified wheat flour should have the characteristic clour and should be free from any objectionable flavors and odour. The flour should be free from insects' worms, fungal infestation, rodent contamination and foreign matter (Johnson et al., 2004).

Table 2.1: Specific requirements of different flour

Parameter	Bake's flour	Home Baking flour	Biscuit Flour	Cracker flour	Self-rising flour	Standard flour	Atta flour	Whole Meal flour	Method of test
Moisture content, % max.	13	13	13	13	13	13	13	13	ES ISO711 or ES ISO712
Crude fiber content, % by mass max.	1.0	1.0	1.0	1.0	1.0	1.5	2.0	2.0	ES ISO5408
Total ash content % by mass max.	0.7	0.7	0.55	0.70	2.0	1.10	2.0	2.0	ES ISO 2171
Residue on sieving through 180 micro sieve, % by mass max.	0.8	0.8	0.5	0.5	0.8	30	55	30	AOAC962.25
Protein content, % by mass min.	11.0	9.0	8.0	8.0	8.0	11.0	12.0	12.0	ESISO20483

Table 2.2: Composition of wheat corn (Johnson et al., 2004)

	Whole kernel	Flour body	Bran	Germ
Weight %	100	82	15	3
Ash %	1.6	0.7	6.3	4.5
Protein	11	10	14	29
Fat %	2	1.4	4.7	10.4
Starch %	60	71	8.6	14
Fibers %	8.5	2.0	48	6.8
Sugar %	2	1.1	4.6	16.2

2.4 Wheat Milling

In prehistoric times, wheat was different milling methods, those methods were mortars, stone and roller milling. Roller mills had allowed for the processing of wheat into white flour whereas using stone mills and mortars results in whole grain flours. The first objective for the milling of white flour using roller mills was to separate as much as possible the endosperm from the bran and germ fractions in the whole grain. The endosperm was required for the manufacture of white flour and it should be free from bran and germ particle contamination. This would result in a product with improved palatability and lengthened shelf life. The second objective for the milling of white flour using roller mills was to reduce the maximum amount of endosperm into fine particles (flour) and to maximize the amount of white flour from the wheat. In conventional milling practice flour was defined as that material which would pass through a sieve with an aperture size of 140 microns in roller mills, milling consists of three basic processes: grinding, sieving and purifying. (Johnson et al., 2004).

2.5 Fortified wheat flour analysis

The chemical composition of fortified wheat flour indicates that fortified wheat flour can be perfect diet as they contain moisture, larger concentration of protein content, ash content, crude fiber and the degree of whiteness of wheat flour be minimum 89% and residue on sieving through 180µ micro sieve % by mass maximum 70-80% (Ethiopian Standards Agency, 2017).

2.5.1 Moisture Content

Samples weight in clean preheated moisture crucible of known weight by using sensitive balance (Tadesse Fenta, 2014). Keep the sample and crucible in an oven 138 °C for an

hour. Cover the crucible and transfer to desiccators and weighed after reaching room temperature. Heat the crucible in the oven for another two hours and re-weight. Repeat this until we obtain constant weight. Calculate the loss of weight as percent of weight and would be expressed as moisture content.

$$\text{Moisture content} = \frac{w_1 - w_2}{w_1} \times 100$$

Where, W₁ = Initial weight; W₂ = weight after drying

2.5.2 Ash Content

Weight empty crucible and put sample on it (Tadesse Fenta, 2014). Place the sample and the crucible in a muffle furnace for 2 hours at 550 °C. Remove the crucible from furnace and place in a desiccators to cool, then reweight it.

$$\text{Ash content (\%)} = \frac{w_1 - w_2}{w_1} \times 100$$

Where, W₁ = Original weight of the sample; W₂ = Weight of sample after cooling

2.5.3 Determination of protein content

All proteins are composed of carbon, hydrogen, oxygen, nitrogen, and sulfur. These elements are found to be present in closely determined percentages.

If in a sample, the amount of one of these elements can be determined then, by knowing its percentage in protein, it is possible to calculate the amount of protein present in the sample.

(x) Gram of protein per (y) grams of flour

$$(x)/100 = (z)$$

(z)/(y) = % of protein content in the flour (Tadesse Fenta, 2014)

2.5.4 Wet gluten content

Weigh 25 gm sample into a dish and add about 15 ml of water to it and make it into dough taking care that all the material was taken into the dough. Keep the dough gently in a beaker filled with water and let it stand for 1 hour. Remove the dough and place it in a piece of bolting silk cloth with an aperture of 0.16mm (No, 10 XXX) and wash it with a gentle stream of water till water passing through the silk does not give a blue color with a drop of iodine solution. Spread the silk tight on a porcelain plate to facilitate scraping. Collect the residue to form a ball, squeeze in the palms to remove excess water, transfer to a watch glass or petri dish and keep it in the oven at 105 ± 1 °C for drying. When partially dried, remove and cut into several pieces with a scissor and

again keep in the oven to dry. Cool in desiccators and weigh. Return it to the oven again for half hour, cool and weigh to ensure constant weight (Tadesse Fenta, 2014).

$$\text{Gluten on dry wt. basis} = \frac{\text{wt. of dry gluten} \times 100 \times 100}{\Delta x \text{ extract wt. of sample} \times (100 - \text{moisture content})}$$

2.5.5 Falling number

The falling apparatus consists of a boiling water bath, matched test tube (to conduct heat at the same time), a stirrer, a stirring apparatus, and a time mechanism. Flour plus a known amount of excess water was placed in a test tube and would be shake to dispersed the flour, the tube would be placed in the apparatus that stirs the sample as if it would heated. At the end of stirring, the stirrer would be dropped the top position. The number of second required for the stirred to fall through the flour-water paste would the falling number. (flour analysis-ndsu north dakota state university)

2.5.6 Determination of crude fiber

Crude fiber was determined by the method of the Association of Official Analytical Chemists' (AOAC, 2000) using the official method 962.09. About 3 gm sample was transferred to 600 ml beaker. After digestion with 1.25% sulfuric acid, washed with distilled water and digested by sodium hydroxide (1.25%), it was then filtered in 76 µm coarse porosity crucible in apparatus at a vacuum of about 25mm. The residue left after refluxing was again washed with 1.25% sulphuric acid near boiling point. This residue was then dried at 110 °C overnight, cooled in desiccator and weighed (M₁). After asking for 2 hours. at 550 °C, it was cooled in a desiccator and weighed again (M₂). The total crude fiber was expressed in percentage as:

$$\text{Total Crude fiber} = \frac{M_1 - M_2}{M_3} \times 100$$

Where: M₃ is the weight of sample

2.5.7 Determination of Carbohydrate

Total percentage carbohydrate was determined by the difference method as reported by (Tadesse Fenta, 2014). This method involves adding the total values of crude protein, crude fat, crude fiber, moisture and ash constituents of the sample and subtracting it from 100. The Carbohydrate content was determined by difference.

$$\%C = 100 - [\%M + \%P + \%F + \%Fb + \%A]$$

Where: C-Carbohydrate content, M-Moisture content, P-Protein content, F-Fat content, Fb-Fiber content and A-Ash content. Value obtained was the percentage carbohydrate constituent of the sample.

2.5.8 Energy Calculation

Energy content obtained by multiplying the mean values of crude protein, crude fat and total carbohydrate by the factors of 4, 9, 4 respectively, taking the sum of the products and expressing the result in kilocalories per 100 gm (Kcal/100gm) sample as reported by (Tadesse Fenta, 2014). The formula for calculating energy is shown below.

$$\text{Energy (kCal/100 gm)} = 4 \times \% \text{ Protein} + 4 \times \% \text{ Carbohydrate} + 9 \times \% \text{ Fat}$$

2.6 Advantages of wheat Flour Fortification Vehicles

There are a number of good reasons why wheat flour was fortified with deficient micronutrients (Johnson et al., 2004).

- ✓ They were food staples, consumed in significant quantities by all age groups and economic classes at nearly every meal. This makes them ideal vehicles for getting deficient nutrients to the general population.
- ✓ Most of the micronutrients being added were naturally present in the whole grain but greatly reduced by the milling refinement process. Many fortification programs simply call for restoring Deficit nutrient levels to that contained in the whole grain, often called enrichment or restoration.
- ✓ The mills producing the bulk of the flour were large, modern and centrally located.
- ✓ Some micronutrients, like folic acid and other B vitamins, were ideally suited for addition to milled cereals. There was no other food staple as well suited for B vitamin fortification.
- ✓ The milling equipment, design and quality control procedures for flour fortification have all been developed and were readily available.
- ✓ There were a number of commercial concerns operating worldwide that supply fortification premix and mill equipment at reasonable prices due to heavy competition.
- ✓ Fortification of wheat flour was an established and proven public health measure with widespread support by the medical and milling communities.

2.7 The Flour Fortification Initiative

The Flour Fortification Initiative was a collective network of individuals and organizations dedicated to making micronutrient fortification of flour standard practice. The Flour Fortification Initiative (FFI) promotes the following. Fortification of all wheat flour with deficit micronutrients where feasible and efficacious allowing every pregnant woman to have access to fortified wheat products where such products were part of their regular diet. The approach of FFI was to involve the private sector right from the beginning as part of Private-Public-Civic sector collaboration. While governments and NGOs could recommend flour fortification, only mills could actually do it. FFI recognizes that flour fortification alone would not solve the world's malnutrition problem. It must be done as part of a wider program that includes supplementation, education and other food-based interventions (WHO / FFI, 2012).

A minimum fortification in new programs was thought to be the addition of 2.4 ppm folic acid and restoration levels of iron using guidelines on the types and levels of iron compounds to use on different types of flours properly leading to learning disabilities, paralysis, and babies being born with little to no brain (Johnson et al., 2004).

2.8 Fortification Effects on Product Quality and Acceptance

As a guiding principle it was essential that the fortification of wheat flour would not change consumer acceptability of the fortified food. It would be ideal for the fortification to be invisible to the consumer. That was, there would be no detectable difference in the appearance, sensory properties or even the price of the fortified product, but this was not always achievable.

2.8.1 Color and Appearance

The visual appearance of any food was the first of the organoleptic senses that a consumer experiences. Therefore if the fortified food had any changes in color and appearance the consumer was more likely to reject the product. At the current fortification levels normally found in wheat there was no adverse impact on color or appearance. Elemental iron powders might cause a slight darkening of flour, while high levels of riboflavin and folic acid could cause a slight yellowing, but these changes were accepted once all flour is similarly treated (Johnson et al., 2004).

2.8.2 Flavor and Aroma

The same criteria for color and appearance apply for flavor and aroma. The consumer must not be able to detect a discernable difference. Any detectable change in flavor and aroma caused by fortification is unacceptable (Johnson et al., 2004).

2.8.3 Shelf Life

As a general rule of thumb the addition of micronutrients to produce a fortified flour of wheat must not reduce the normal or expected shelf life of the flour. Any reduction of shelf life would result in lost products and reduced consumer acceptance of the food. The usual cause of reduced shelf life would be due to the development of rancidity in the flour caused by soluble iron and zinc salts. This was particularly true for high extraction and whole grain flours (Johnson et al., 2004).

2.8.4 Taste and Mouth feel

There must be no change in product texture and mouth feel. Rancidity would affect the taste and mouth feel as well as aroma and flavor of both the flour and the finished products as consumed. Rancid products had a slightly soapy mouth feel and a distinctive unpleasant odor (Johnson et al., 2004).

2.8.5 Sensory Testing

There had been extensive testing and experience to show that fortification could be accomplished without adversely affecting any of these sensory properties in standard products such as flour, bread, cakes, instant noodles and pasta. However, there are some cereal-based foods unique to different regions of the world that had not been tested. These should be tested prior to starting a general fortification program (Johnson et al., 2004).

2.8.6 Reducing Phytic Acid

High levels of phytic acid in grains were a problem because they inhibit the absorption of iron. Whole grain wheat contains nearly 1% phytic acid. Reducing this level of acid can improve the absorption of these minerals. Milling refinement lowers the amount of phytic acid in flour by 60% to 90% depending on the extraction rate, but the remaining phytic acid was still strongly inhibitory. The final level of the phytic acid was closely related to ash content - the lower the ash, the lower the phytic acid. Common practices of fermentation, soaking and germination further reduce the level through the action of phytase, which was naturally present in cereals. One potential solution was to add the phytase enzyme, but the dough must be allowed to sit for some time prior to baking for the

enzyme to have any effect. Yeast fermentation during bread baking lowered the phytic acid from added bran by 60% after two hours and up to 85% for longer periods. The lower the pH during fermentation, the more phytic acid that was removed. However, the molar ratio of phytic acid to iron should be decreased to at least 1:1 and optimally less than 0.5:1 to achieve a meaningful increase in iron absorption. Getting this low a molar ratio was difficult. In order to reach a final molar ratio below 1.0 from wheat containing 0.9% phytic acid, one needs at least 50 ppm iron, a 75% reduction in phytic acid on milling and a 75% reduction on baking. Unfortunately, non-fermented products like noodles and pasta would never achieve this low a ratio (Johnson et al., 2004).

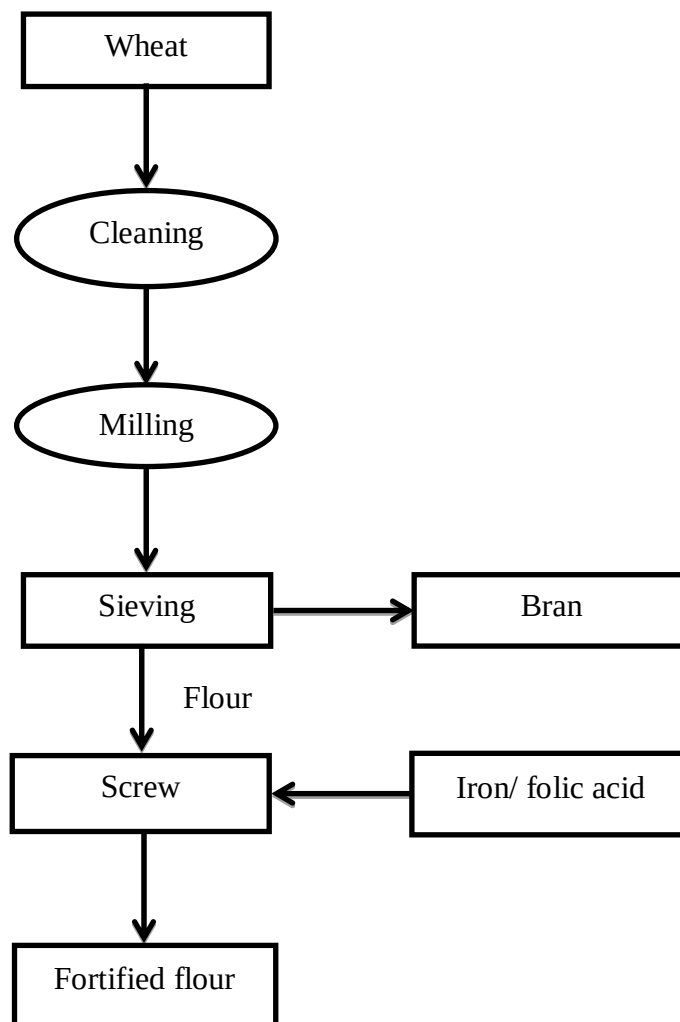


Figure 2.2: Industrial fortified wheat flour Processing

2.9 Properties of minerals used in cereal fortification

The different essential minerals fall in one of the following classifications that depend on their concentration in the body and dietary requirement. This difference in the quantity

needed had a major impact on cost and other aspects of mineral fortification (Johnson et al., 2004).

2.9.1 Iron fortification

The effectiveness of iron fortification had been demonstrated in several world regions. Iron fortification of infant formulas had been associated with a fall in the prevalence of anemia in children aged less than 5 years in the United States. In Venezuela, wheat and maize flours have been fortified with iron (as a mixture of ferrous fumarate and elemental iron), vitamin A and various B vitamins since 1993. A comparison of the prevalence of iron deficiency and anemia pre- and post-intervention showed a significant reduction in the prevalence of these conditions in children. Information about the efficacy and effectiveness of flour fortification in particular is urgently needed (Lindsay Allen & Hurrell, 2006).

There was a great need to increase the level of absorbable dietary iron due to the extremely high incidence of iron deficiency anemia (IDA) in many countries. Iron was the greatest complexity and produces more problems in fortification than any other micronutrient. Creating an effective iron fortification program for cereals could be very challenging. Iron was included in all the cereal fortification programs in the world to date. Despite lingering questions on its effectiveness, it would not be wise to exclude it from cereal fortification programs in countries with high levels of IDA. Because of the importance and difficulty in iron fortification, a number of good publications have already been made on this topic, which could be consulted for additional information. A major concern was which iron source to use. The key recommendations of WHO are given in Table 2.3.

Table 2.3: Suitable Iron Fortificants for Cereals (According to WHO Guidelines)

Cereal product	Fortification
Low extraction (white) wheat flour	Ferrous sulfate, dried (bakery flour only) Ferrous fumarate Electrolytic iron (2X amount)* Encapsulated ferrous sulfate
High extraction wheat flour	NaFeEDTA Ferrous fumarate (2X amount) Encapsulated ferrous sulfate (2X amount) Encapsulated ferrous fumarate (2X amount)
Pasta or semolina	Ferrous sulfate, dried

If X was the amount of iron that would be normally added in an ideal situation (e.g. 30 ppm), 2X means that twice that amount of iron should be used (e.g. 60 ppm) to account for a lower bioavailability, either due to the nature of the added iron source or the absorption inhibiting properties of the food to be fortified. The main criteria in choosing an iron source were bioavailability, effect on product quality and cost.

Function of iron: Major role in delivering oxygen to tissues. Contributes to the regulation of the immune function, Iron Deficiency Anemia (IDA) can cause extreme fatigue and depression ,IDA impacts cognitive development and productivity, IDA can lead to maternal haemorrhage and is associated with 20% of all maternal deaths (Johnson et al., 2004).

Cost-effectiveness of iron fortification: In iron fortification, the cost for personnel, facilities, materials, and iron was minute compared with the value of the food being fortified. In fact the incremental cost of iron fortification of wheat flour was generally insignificant—usually less than 1% of the wholesale cost of flour. The added cost of fortifying wheat flour with iron has been calculated to be typically less than US\$1.00 per metric ton (MT) (Nestel & Nalubola, 2000).

2.9.2 Folic acid fortification

The introduction of the mandatory fortification of wheat flour with folic acid in the United States in 1998 was accompanied by a significant reduction in the prevalence of neural tube

defects and in plasma levels of homocysteine (Lindsay Allen & Hurrell, 2006). Elevated plasma homocysteine has been identified as a risk factor for cardiovascular disease and other health problems. Even though these outcomes might have been due to other factors, there was certainly an increase in folate intakes and an improvement in folate status among the population in the period immediately following the implementation of the new legislation. Similar improvements in folate status have been seen after the commencement of folic acid fortification of wheat flour in Canada (see Figure 2.3).

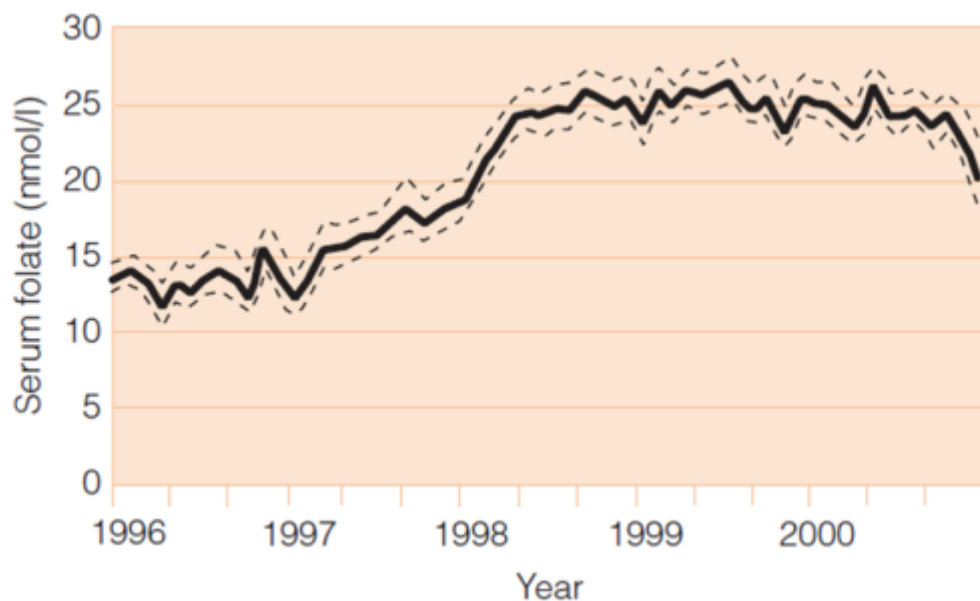


Figure 2.3: Effect of flour fortification with folic acid on the folate status of elderly Canadian women (Lindsay Allen & Hurrell, 2006)

Serum folate concentrations in a cross-section of 15 664 Canadian women aged 65 years and older in relation to the introduction of flour fortification in mid-1997. Data are presented as mean values (solid line) with 95% confidence limits (dotted lines).

Folic Acid: Folic acid had been included in cereal fortification programs for only the last ten years, but had proven so successful that now it was considered a leading reason to fortify cereal staples, even in developed countries with few overt micronutrient deficiency problems. The initial reason to include folic acid was to prevent the neural tube birth defects (NTD) of spina bifida and anencephaly. These could occur if the mother has insufficient stores of folic acid during the first few weeks of pregnancy. Folic acid supplements taken prior to pregnancy will help prevent this but many women are not aware. They were early on in pregnancy when it was needed or they simply fail to take supplements. It was nearly impossible to get adequate intakes of folate from natural

sources, particularly so since the natural folates have only 60% of the vitamin activity of synthetic folic acid. The level of folates in cereals was low, even in whole grain products. The surest way to get folic acid to the whole population was to add it to a food staple, with wheat flour and maize meal being the preferred vehicles, particularly if it can be included with an existing or planned fortification program. A standard recommendation in the prevention of NTDs was to have women consume 0.4 mg/day of synthetic folic acid, not including natural folate sources, and this was only achievable with mass fortification of a cereal staple such as flour (Johnson, 2001).

Folic acid had a light yellow color, which does not carry over to the flour or cereal food because it was added at such low levels, typically from 1.5 to 2.4 ppm. There was some loss of the vitamin on exposure to light and during cooking and baking, but not as much as originally supposed. The biggest loss of folate would occur in cookies and pasta, but this was probably no more than 20%. Folic acid was difficult to analyze, so levels reported in fortified flour and baked products can have considerable assay error.

Function of Folic Acid: Folic acid was required for appropriate development of the brain and spinal cord of babies, pregnant women with a low folic acid status are at increased risk of having a baby with a neural tube defect, and Neural tube defects are a group of conditions in which the spinal cord does not close.

2.9.3 Fortification Premixes (iron folic acid)

A premix (iron and folic acid) or master mix was a blend of micronutrients used to fortify flours. Advantages of vitamin/mineral premixes (iron and folic acid) is such as; Nutrient ratio, standardized addition rates, excipient, single weighing and technical support (Johnson, 2001).

Table 2.4: Requirements for levels of micronutrients in fortified wheat flour (CES compulsory Ethiopian Standards)

S.N ^Q	Nutrient	Fortificant compound	Recommended factory level, mg/kg	Regulatory levels, mg/kg	
				Minimum	Maximum
1	Vitamin B1	Thiamin mononitrate ,activity level,81%	9	4.6	NA ¹
2	Vitamin B2	Reboflavin,activity level,100 %,min	6	3.3	NA ¹
3	Niacin	Niacinamide,activity level,99% min	50	30	NA ¹
4	Vitamin B6	Pyridoxine, activity level 82 %,min,	6	3	NA ¹
5	Folate	Folic acid activity level,100%,min,	2	1.1	3.2
6	Vitamin B12	VitaminB12(water soluble) activity level.0.1% min,	0.02	0.01	NA ¹
7	Zinc	Zinc oxide, activity level 80% min	80±10	70	90
8	Iron	NaFeEDTA activity level 80% min	30	20	40
		Ferrous furnace activity level 32% min,	40	30	60

2.9.4 Packaging, storage and handling of premixes

Vitamin/mineral premixes should be packaged in air and water tight containers well protected from exposure to light. Typical packaging was 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 had 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. There might be some allergic skin reactions to flour fortificants such niacin. It was therefore recommended that the operator use gloves and long sleeve shirts when handling the product. A common occurrence was skin reddening caused by the vasodilatation effect of niacin. This effect was transitory and not dangerous but it can be annoying.

Upon receipt of the shipment, the production lot number should be recorded and retained. It was 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 was particularly the case with vitamin A. Unopened packages of premixes containing vitamin A have an effective shelf life of six months in warm climates. The shelf life of premixes containing minerals and only B vitamin was up to three years if unopened. Once a premix box has been opened it should be used within a few weeks.

2.9.5 Mill Fortification Methods

Mill fortification involves adding standard quantities of micronutrients to a set quantity of food and mixing them together so as to achieve a uniform product. There were three different types of methods that have been used to fortify flour or meal in large, continuous milling operations.

Flour Fortification in Continuous Systems: When micronutrients were added in continuous systems, they are added as a free-flowing, dry powder premix. The premix was continuously metered into the flour stream at a dosage rate dependent on the flour flow. It was important to ensure that the dosage was correct and that the flour flow and premix delivery rate was known and consistent. The premix could be added to flour at the end of

the milling process, or it could be added after milling during packing or load-out on condition that adequate mixing could be provided. The equipment needed to fortify flour in a continuous system includes:

1. A dry powder “feeder” or “dosifier” to meter out the fortificant or premix
2. A means to agitate the fortificant or premix so that it feeds smoothly and uniformly without bridging.
3. A mechanical or electronic means of adjusting the rate of flow of the premix
4. A means to deliver the premix from the feeder to the flour
5. Some level of mixing after the premix has been added to the flour

2.9.6 Addition and Mixing Design Delivery Systems

Gravity feed system: The gravity feed system 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 were ideally suited to the installation of gravity feed locations, whereas older mills might 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.

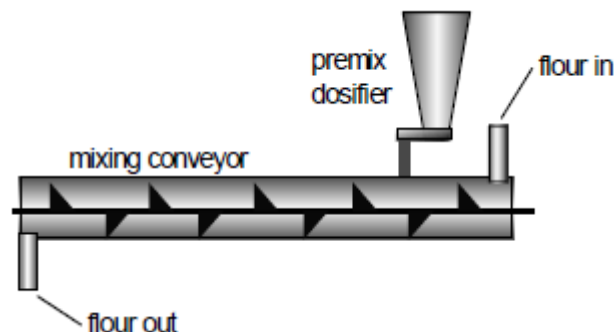


Figure 2.4: Gravity Feed Method of Premix Delivery (Johnson, 2001)

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 might be well above the floor. This requires construction of a platform from which the hopper could 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 shoot.

Alternatively, the feeder could be connected to the flour discharge spout of a plan sifter. 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 3-meter distance requirement may be lifted in some mills where the flour was 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.

2.9.7 Flour Production Rate Determination

Use following procedure to determine actual flour production (not rated capacity) in kg or tons per minute.

1. While the mill was running count number of bags packed per 20 minutes or use on-line flour scale (if one is installed).
2. Calculate the flour production rate using the following formula. This was the actual production rate per minute.

Weight of bags in kg x number of bags per 20 minutes divided by 20 = kg flour per minute.

2.9.8 Premix Feed Rate Calibration

Use this was to determine the feed rate of premix in grams per minute required to fortify the flour at the recommended level (Kaishozi, n.d.).

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.



Figure 2.5: Premix addition-industry (Kaishozi, n.d.)

2.9.9 Quality Control in Mill

Quality assurance and quality control for fortification. The following steps should be taken to ensure on-line quality control of the fortification process (Johnson, 2001):

1. Check Weighing: The weight of premix discharged over a specific time (1 or 2 minutes) was measured and compared to the target weight for the premix.
2. The iron spot test was carried out on the flour every 4 hours and at the start and end of each production run.
3. Production Records: Production records of the amount of fortified flour produced should be maintained.
4. Inventory Records: Premix inventory and usage records need to be kept.
5. Premix Usage Reconciliation: Reconciliation of actual usage versus target need to be kept.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Equipment and materials

The major equipment and apparatus that were used in this study are perten im9500 , filter paper, oven , analytical balance, beakers, grinder, crucible, rapid moisture analyzer , sieve ,mask, glove ,volumetric flask, test tube, micro doser,spatula and uv spectroscopy.

All the materials that were used in this study are wheat, water, iron, folic acid and distilled water was used throughout the experiment.

The raw material used for producing flour was different type of wheat of groups named as soft, semi-soft, semi-hard, hard, and durum wheat. The sources of this wheat were mainly from local area (bale and aris zone, amhara rigon) and rarely from abroad. Sample collection date was 15.10.15 Ethiopian colander. Iron and folic acid buying from Germany.

Wheat with high hectoliter weight was giving a better extraction, but. This was corrected only with in the some type of wheat. Hector liter weight test shows the soundness of the wheat fully grown kernels & kernels with high mineral were related to high hectoliter weight with in the same type of wheat (high hectoliter weight gives high yield). The accuracy of this apparatus was not 100% but this was a widely used method for wheat tests. The test should be done always in the same & exact manner otherwise it would give false results (variation in weight). The higher the hectoliter weight, the better is the wheat. . (ISO 22000:2018/Africa PLC/laboratory manual)

3.2 Methods of wheat testing

First step was to put the scale-stand on the wooden casing, and then the scale beam was hung on the center of scale-stand with one side counter weight and other side measuring cylinder with bottom weight. Once it was balanced, the measuring cylinder should be taken out along with the bottom weight put the flat unite in cylinder between the slot of the measuring blinder, then put bottom weight on the top. Fill the pouring cylinder with. Wheat put filling cylinder on top of admeasuring cylinder, then pour wheat on filling cylinder. The pouring time should be 8 seconds fur ¼ liter tester & about 12 seconds for 1 liter cylinder. Pull flat knife fast as possible without shaking the apparatus once the flat

knife was taken out, the bottom weight and wheat would fall into measuring cylinder. Then insert the flat knife again to level the wheat to the level of measuring cylinder. Extra wheat in the filling cylinder has to be removed. Then hang that measuring cylinder on to the scale & measure the weight. (ISO 22000:2018/Africa PLC/laboratory manual)

Wheat's with hectoliter weight 74 kg/hl or less were generally regarded as poor where as those with 78 kg/hl & 82 kg/hl were considered to be good & very good respectively. Average value of hard wheat was 80-85 kg/hl, soft wheat 72-78 /kg/hl. Note that hectoliter weight was influenced by shape & size of wheat kernel, percentage of moisture, percentage of foreign matter, percentage of light seeds, infested kernels, broken & shriveled wheat. . (ISO 22000:2018/Africa PLC/laboratory manual)

3.2.1 Estimation of gluten of wheat flour

The dough obtained by mixing wheat flour with water possesses the character of plasticity & elasticity characteristics of vital significances' both during handling of the dough as well as in its end performance. The properties referred to above could be attributed to the gluten component of the dough formed mainly by the interaction of water insoluble proteins of wheat in the presence of water. (ISO 22000:2018/Africa PLC/laboratory manual)

Principle: Gluten in samples of flour could be estimated by washing the dough ball ensure proper hydration after wash the starch washed out by kneading gently in a gentle stream of water over fine sieve of silk till the washed liquid is clear

Calculation:- wet gluten (%) = $A/C \times 100$, Dry gluten (%) = $B/C \times 100$

A - Weight of wet gluten, B - Weight of dry gluten and C - Weight of flour

3.2.2 Impurity determination

Impurities could be any foreign matter, broken grain, shriveled grain or immature grain, other grains or grains of constructing varieties sprouted grains, insect damaged grains, frost-damaged, grains, with discolored germs grains, weed seeds, ergot, unsound grains, smutty grains, chaff, and other impurities

Reception: - incoming wheat sample taken to the laboratory the sample could be checked on rapid grain analyzer. The machine generates analysis result in 30 seconds such as:- Wheat grain quality control fast analysis before grain intake: Moisture content ,Protein content ,Hectoliter weight ,%Impurities ,Gluten quality and sedimentation value of Zeleny. The analysis result is printed and given to the purchasing section. The wheat could be

purchased if it meets the company specification and both agreed on price. If the wheat purchased it was required to be inspected for each sack by quality control assistant clerks. The wheat was then unloaded manually by manpower and cased on plastic palet based on purpose of purchase either for pasta, or macaroni or for bread. The data is logged in the following format developed by raw wheat analysis result.

Company standard, Moisture < 15%, Impurity < 7%, HLW >73kg/hr and Gluten > 23.0. The wheat was cleaned for physical impurities and tempering .then reset wheat indifferent hours depend on wheat type and then milling.

3.2.3 UV analysis method

A low-cost and simple spectrophotometric method was developed for determining the concentration of folic acid in distilled water and iron as encapsulated ferrous fumarate. The method is based on absorption from 200 nm-800 nm, which is selective for folic acid in the presence of products of degradation of folic acid. High recoveries of folic acid were obtained from distilled water and fortified bread, confirming that the method is accurate and precise. The analytical method can be used to monitor the progression of folic acid degradation in the distilled water and fortified bread. The analytical method is stable and can withstand exposure to light for at least 5 h needed to complete the analysis (Modupe et al., 2020)

3.2.4 Flour fortification method

Based on the preliminary proximate composition and physicochemical studies, five mixing of flours and premix were developed. Five batches of wheat flour and iron mixture were prepared by mixing at flour levels: The first mixing ratio contained 100gm wheat flour and 35gm iron. The second mixing ratio contained 100gm wheat flour and 40gm iron. The third mixing ratio contained 100gm wheat flour and 45gm iron).The fourthly contained 100gm wheat flour and 50gm iron and the fifthly mixing ratio contained 100gm wheat flour and 55gm iron. The five different flour mixtures were prepared in a mixing screw for 20 minutes. The formulated mixing of flour and premix are shown in the Table 4.1 below. (Tadesse Fenta, 2014)

After mixing, the mixture was packed in Plastic bags and stored blow 25⁰c for further use. And also mixing of wheat flour and folic acid five batches of wheat flour and folic acid mixture were prepared by mixing at flour levels: The first mixing ratio contained 100gm wheat flour and 0.45mg folic acid. The second mixing ratio contained 100gm wheat flour

and 0.51mg folic acid. The third mixing ratio contained 100gm wheat flour and 0.54mg folic acid. The fourthly contained 100gm wheat flour and 0.56mg folic acid and the fifthly mixing ratio contained 100gm wheat flour and 0.58mg folic acid. The five different flour mixtures were prepared in a mixing screw for 20 minutes. The formulated mixing of flour and premix are shown in the Table 4.2 below.

After mixing, the mixture was packed in Plastic bags and stored blow 250c for further use. (Tadesse Fenta, 2014)

3.2.5 Methods Used to Add Premix to the Flour

Continuous Systems: Most larger and newer mills operate within a continuous system. The premix was continuously metered or fed into the flour flow using a precision micro “feeder”(also referred to as a dosifier). The dosage rate was controlled and depends on the rate of flour production of flour flow.

Table 3.1: Frequency of micro feeder with wheat flour

Amount of wheat flour qt/hr	Amount of wheat flour kg/min	Amount of premix in gram	Frequency of micro feeder
35	58	35	15.9
36	60	36	16.3
37	62	37	16.7
40	67	40	18.1
39	65	39	17.6
40	67	40	18.1
41	68	41	18.5
42	70	42	19.0
43	72	43	19.4
44	73	44	19.9
46	77	46	20.8
47	78	47	21.2
48	80	48	21.6
49	82	49	22.1
50	83	50	22.5
51	85	51	23.0
53	88	53	23.9
54	90	54	24.3
55	92	55	24.8

3.2.6 Delivery Mechanisms of premix

There were two main ways to deliver the premix to the flour: pneumatic and gravity feed. Africa privet limited company use the second one gravity method. In gravity feed system, the feeder was placed above a flour conveyor. The premix was dropped directly into the

flour as it flows through the conveyor. Most often, the feeders were placed above or near the flour collection conveyor that blends the various flour streams.

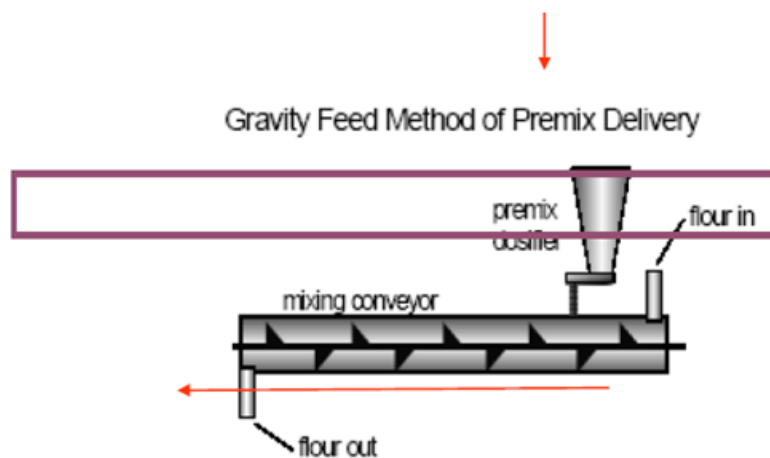


Figure 3.1 Gravity feeder; Feeder Types screw feeder: Discharge and agitator screws and Variable speed drive DC motor (Johnson et al., 2004)

3.2.7 Packaging and labeling of fortified wheat flour

Packaging: Fortified wheat flour should be packed in suitable packages which should be cleaned, sound, free from insects and fungal infestation, and the packing material should be food grade quality. (CES73 compulsory Ethiopian Standards)

Fortified wheat flour should be packed in containers which would safeguard the hygienic, nutritive, technological and organoleptic qualities of the product. The containers, including packaging material, should be made of materials which are safe and suitable for their intended use. They should not impart any toxic substance or undesirable odour or flavor to the product as specified in Ethiopian standard 921. Each package should be securely closed and sealed. quality. (CES73 compulsory Ethiopian Standards)

The inner liner should conform to the size, thickness, density and weight specified below; size fit to outer pp bag, thickness 100 micron, density 92 g/m³ and weight 83-95g (viable with size of inner liner). (CES73 compulsory Ethiopian Standards)

Labeling: The labeling should comply with the requirements of Ethiopian standard 73, and should be legibly and indelibly marked with the following;

- ✓ Product name as “fortified wheat flour product derived from it”
- ✓ Name, address and physical location of the manufacturer/packer/ importer,
- ✓ Lot or Batch number
- ✓ Brand name or registered trade mark, fortification logo if any;
- ✓ The declaration “human food”

- ✓ Storage instruction as “store in a cool dry place await from any contamination”, date of manufacture;
- ✓ Best before date;
- ✓ Instruction on disposal of used package; and country of origin

Safety: Fortified wheat flour should be free from objectionable matter; not contain any substances originating from micro-organisms or any other poisonous or deleterious substance such as anti-nutritional factors, heavy metals or pesticide residues, in amount which may represent a hazard to health.(CES73compulsory Ethiopian Standards)

Table 3.2: Sensory parameter of fortified flour

Criteria	Unit	Reference method	Minimum	Target	Maximum
Appearance	-	Organoleptic	-	Powder	-
Color	-	Organoleptic	-	Yellowish	-
Total plate count	cfu/g	-	-	10000	-
Yeasts and moulds	cfu/g	-	-	500	-
Salmonellae	/25g	-	-	-	-
Enterobacteriaceae	cfu/g	-	-	10	-

Table 3.3: Quality specification of fortified bread flour. (UNIDO project YA/ETH/03/436/11-55)

Bread flour Parameter	Company standard
Odor	Fresh
Color	white to creamy white
ash content(%)color	Max 0.65/ ,min-1
Moisture content (%)	Max 14.5
Wet gluten (%)	Min 58 (elastic)
Water absorption (lit/quintal)	Min 58/quintal
Falling number (sec)	250-350 sec
Granulation (150 micrometer sieve)	70-90%

3.2.8 Fortified bread manufacturing process

The process of bread manufacturing was divided in to two main parts each of which was given equal important in resulting acceptable end products .they were dough making that includes kneading ,development and leavening. The other part was baking that changes the dough in to a petting and digestible product. Raw materials for bread making are flour, water, yeast, dough improver and salt. After mixing the dough need Fermentation, Punching, Panning and Molding. (UNIDO project YA/ETH/03/436/11-55)

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1 Mixing ratio of fortified wheat flour

4.1.1 Development and characterization of iron fortified wheat flour

Iron added to flour in accordance with the range of maximum and minimum standard. (30-60mg) at constant flour 100gm in different amount iron content

Table 4.1 Result of 100gm flour mixed different amount of iron (fortified flour)

Parameter	Amount of iron add in mg				
	35	40	45	50	55
Test result in %					
moisture	13.1	13.0	12.8	12.5	12.0
protein	15.0	15.5	16.0	16.5	17.0
ash	0.70	0.75	0.78	0.80	0.82
Color L	92.4	91.4	90.4	90.0	89.5
Wet gluten	28.0	28.5	29.0	29.5	30

Addition of iron to wheat flour was some nutritional parameters are change, these are moisture content decrease, protein content increase, ash content increase and degree of whiteness decreases. From these result adding difference content to flour

4.1.2 Development and characterization of folic acid fortified wheat flour

Folic acid added to flour in accordance with the range of maximum and minimum standard (0.40mg – 0.6mg) at constant flour 100gm in different amount of folic acid.

Table 4.2: Result of 100gm flour mixed with different amount of folic acid (fortified flour)

Parameters	Amount of folic acid add in mg				
	0.45	0.51	0.54	0.56	0.58
Test result in %					
Moisture	13.9	13.7	13.7	13.6	13.6
Protein	11.0	11.2	11.4	11.5	11.3
Ash	0.60	0.65	0.67	0.69	0.7
Color L	89.5	89.5	89.3	89.2	88.9
Wet gluten	24.5	24.8	25.0	25.1	25.5

In these result the protein content was increase, degree of whiteness decrease, gluten content increase and moisture content is decrease.

Principle of Organoleptic Tests

Organoleptic means making an impression on an organ of special sense: sight, smelling, and taste. The physical and chemical characteristics of foods are stimuli for the eye, nose and mouth whose receptors initiate impulses that travel to the brain where perception occurs. Perception or the correlation of sensory impressions determines whether a food will be accepted or rejected. Sensory evaluation is a valuable tool on solving problems involving food acceptability. It is useful in product improvement, quality maintenance, new product improvement, and market research. (Tadesse Fenta, 2014)

4.2 Sensory Evaluation of Products

Sensory evaluation with 9-point hedonic scale for the products was carried out by 14(6 males and 8 females) panelists who were selected from the staff of Africa privet limited company Adama. They were requested to express their perceptions about the products by scoring the following attributes: color, apprance, odor, and mouth feeling, and softness, internal texture, biting characteristics, volume and overall acceptability.

The sensory attributes; visual color apprance, odour, mouth feeling, and softness, internal texture, biting characteristics, volume and overall acceptability were evaluated using a seven point 8 (v.good), to 6(extremely like). Just before the test session, orientation was given to the judges on the procedure of sensory evaluation.

Table 4.3 Test result of not fortified wheat flour (ES1052:2021)

S.No	Characteristics tested	Standard requirements	Test result
1	Moisture,% by mass, max	14	11.85
2	Protein(on dry basis),%by mass	–	9.7
3	Total ash, %by mass, max	–	0.62
4	Acid insoluble ash,% by mass max	0.05	0.04
5	Fat acidity (on dry basis)% by mass	70	55.67
6	Crude fiber,% by mass max	–	1.4
7	PH value	4.5 -6.5	6.42
8	Cadmium,(Cd)mg/kg	–	0.08
9	Copper content(Cu),mg/kg,max	–	2.3
10	Iron content(Fe),mg/Kg	–	25.3
11	Chromium (Cr),mg/kg	–	Not detected
12	Cobalt (Co,mg/Kg	–	Not detected
13	Zink(Zn),mg/kg	–	7.9

Table 4.4: Test result of fortified wheat flour (CES309 compulsory Ethiopian Standards)

Characteristics tested	Test method /specification	Standard requirements			Test result	Comment
		Min	Nom	Max		
Moisture % by mass	ES ISO712:2018	-	-	14.0	13.99	passed
Total ash (on dry basis),%by mass	ES ISO2171:2022	-	-	0.7	0.67	passed
Protein (5.70)(on dry basis),%by mass	BCTL/SOP/M014.01	8	-	16	12.15	passed
Acid insoluble ash (on dry basis),%by mass	ES 1066:2005	-	-	0.05	0.04	passed
Fat acidity(on dry basis),%by mass	ES ISO 1063:2005	-	-	0.07	0.03	passed
Crude fiber(on dry basis),%by mass	BCTL/SOP/M017.01	-	-	1.0	0.98	passed
PH value	ES 1060:2005	4.8	-	6.5	6.12	passed
Particle size (granularity)on 180 micro meter sieve, by mass	ES ISO5223:2015	99.5	-	-	99.8	passed
Water absorption,5by mass	ES ISO 5530-3:2015	60	-		60.0	passed
Arsenic(as AS),mg/kg	AOAC 2015,01ICP-MS	-	-	0.1	0.006	passed
Lead (as Pb),mg/kg	AOAC 2015,01ICP-MS	-	-	0.1	0.03	passed
Cadmium(as Cd),mg/kg	AOAC 2015,01ICP-MS		-	0.1	0.003	passed
Zinc oxide (as ZnO) mg/kg	AOAC 2015,01ICP-MS	70	-	-	78	passed

From these two result the difference was big that means fortified flour had more protein, ash and zinc content than no fortified flour. Because of those fortifying wheat flour was important.

Table 4.5: Quality specification for end product bread (CES309 compulsory Ethiopian Standards)

Appearance	Golden yellow
Odour	Fresh
Test in mouth	Fresh
Biting characteristics	Nom stick
Internal texture	Soft and not caturated-
Softness	Excellent
Volume	Proper in a gram

Table 4.6: Test result of fortified bread (CES309 compulsory Ethiopian Standards)

S.No	Characteristics tested	Specification/test method	Standard requirements			Test result	Comment
			Min	Nom	Max		
1	Moisture content,% by mass	ES 1064: 2005	-	-	-	38.08	-
2	Total solid content %by mass	ES 1065 :2005	60	-	-	61.92	passed
3	Acid insoluble ash (on dry bases)%by mass	ES 1066 :2005	53	-	0.1	0.1	passed
4	PH value	ES 1060 :2005	5.3	-	6.0	5.63	passed
5	Total ash(on dry bases),%by mass	ES ISO 2171 :2005	-	-	-	1.69	-
6	Physical parameter	ES 1058 :2005	-	-	-	good	-
7	Fat(on dry bases),%by mass	Extraction method	-	-	-	0.31	-
8	Protein(N*5.7),(on dry basis)% by	Kjeidehal method	-	-	-	15.68	-

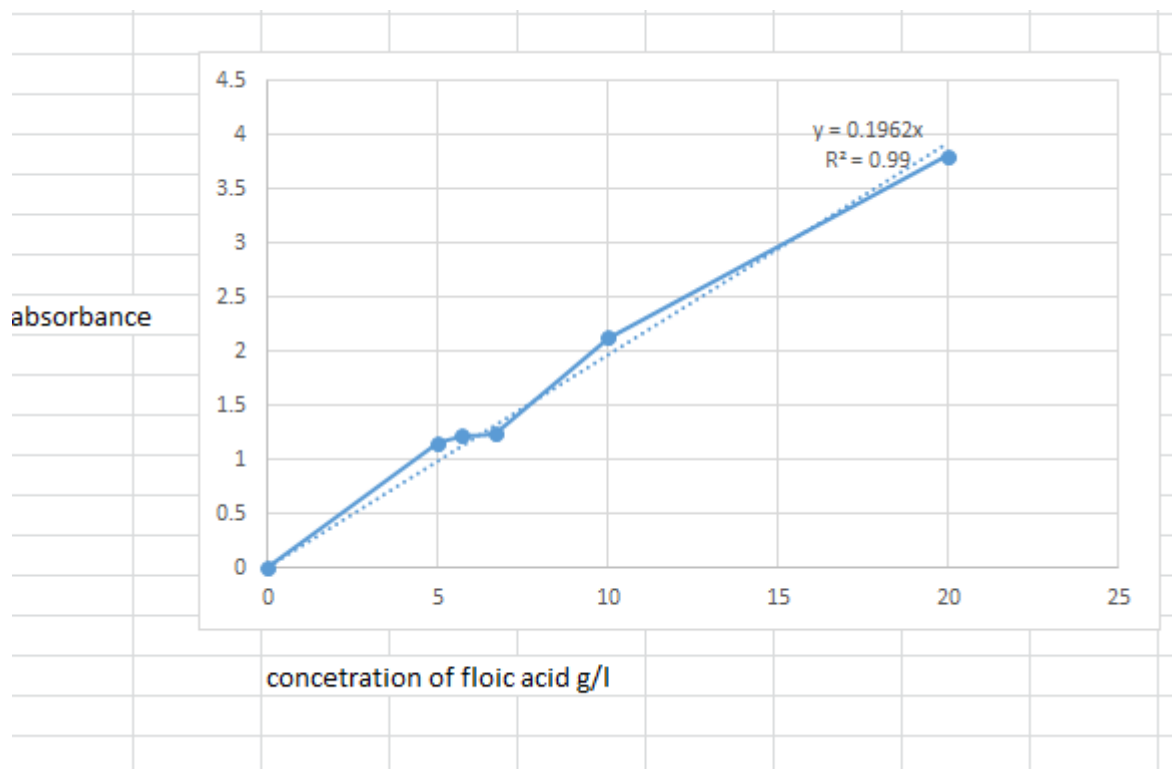


Figure 4.1 graph of concentration versus absorbance of folic acid

Table 4.7 concentration of folic acid and amount of absorbance

Concentration g/l	5	5.7	6.67	10	20
absorbance	1.148	1.211	1.234	2.12	3.802

To know amount of folic acid in fortified bread from the above graph $y=0.1962x$ find concentration of folic acid after 30min dalution.60min and 120min

A. after 30min absorption, $abs=\text{£CL}$, at wavelength 316nm $abs=2.159$

Abs=2.159, $\epsilon = 0.1962$, length (L) = 1 $C_{30\min} = 11.0\text{gram/liter}$

B. After 60min absorption $\text{abs} = \epsilon CL$ at wavelength 310nm $\text{abs} = 2.50$

Abs=2.50, $\epsilon = 0.1962$, length (L) = 1

$C_{60\min} = 12.74 .0\text{gram/liter}$

C. after 120 min absorption $\text{abs} = \epsilon CL$, at wavelength 247.50nm $\text{abs} = 2.196$

Abs=2.196, $\epsilon = 0.1962$, length (L) = 1

$C_{120\min} = 11.19 \text{ gram/liter}$

From this result the conclude was after 60min absorption was best

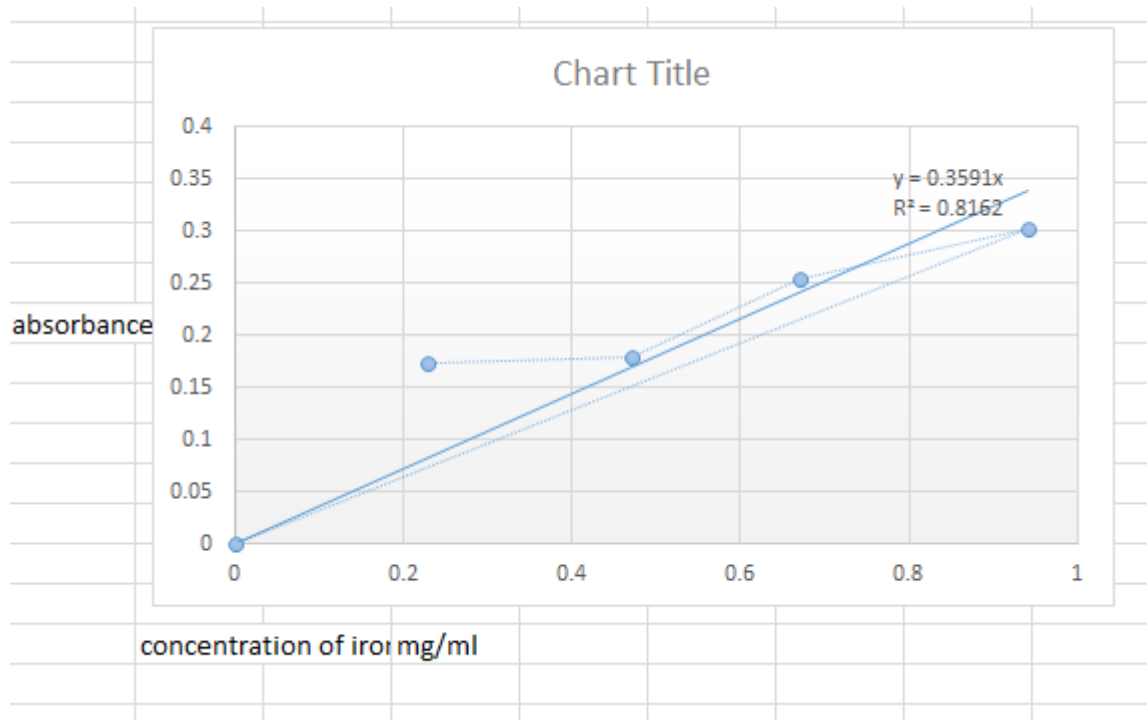


Figure 4.2 graph of concentration versus absorbance of iron

Table 4.8 find absorbance of iron by using UV method

(Modupe,o,,Maurras,j,B,,&Diosady,L,L,(2020)

concentration mg/ml	0.94	0.67	0.47	0.23
absorbance	0.302	0.253	0.178	0.173

To know amount of iron in fortified bread from the above graph $y = 0.3591x$ find concentration of iron after 30min dilution, 60min and 120min

A. after 30min absorption $\text{Abs} = \epsilon CL$, at wavelength 279.0nm $\text{abs} = 2.605$

Abs=2.605, ϵ = 0.3591, length (L) = 1

C_{30min} =7.25mg/ml

B. After 60min absorption abs= ϵ CL, at wavelength 278.50nm abs=2.932

Abs=2.932, ϵ = 0.3591, length (L) = 1

C_{60min}=8.18mg/ml

C. after 120 min absorption abs= ϵ CL, at wavelength 316.50nm abs=2.094

Abs=2.094, ϵ = 0.3591, length (L) = 1

C_{120min}=5.83mg/ml

From this result the conclude was after 60min absorption was best

Cost of Fortifying Wheat Flour

Life of micro dosing unit estimated to be 10 years

Average capacity of 150 ton of Africa privet limited company 35qt/hr or 840 qt per day.

Daily consumption of premix is 50.4 kg. Cost of premix for daily consumption is 25632.93 birr and company working day is 250 per a year.

Table 4.9: Cost analysis of fortified bread (Nestel & Nalubola, 2000)

Item	Price in birr
Cost of premix per kg	508.59
Cost of unfortified flour of 100kg	7700
Cost of fortified flour of 100kg	7730.51
Cost of premix for 600gram(used for 100kg flour)	30.51
Cost of unfortified bread 100 g	8
Cost of fortified bread 100 g	11.48

From this table we conclude fortified bread cost is not much higher than unfortified bread so eating fortified bread is better than unfortified bread, the difference is 11.48 - 8 =3.48 birr.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This study was conducted to investigate the effect of mixing ratio and operating conditions (quantity of flour) on the physicochemical and sensory properties of fortified product from iron-folic acid and wheat flour. Mixing tests were conducted using blend ratio of iron with flour and folic acid with flour.

Mixing ratio, ash, protein, degree of whiteness, wet gluten and moisture content were found to have significant effects on the product properties iron-folic acid mixing increased protein, total ash and wet gluten but reduced moisture content and degree of whiteness. Mixing ratio was the most dominant factor affecting physical, functional and sensory properties of fortified bread.

UV was a low-cost and simple spectrophotometric that developed for determining the concentration of folic acid and iron in distilled water. From this method knowing amount of folic acid and iron release from stomach at different time that means at 30 minute, 60 minute and 120 minute. From this result of best time that absorbing after 60min a best for both iron and folic acid absorption.

Therefore, the iron-folic acid mixing with flour production can be considered as the nutritive food for pregnant women and her child. In conclusion, since fortified problems in the developing countries have frequently been identified as protein energy malnutrition, fortified bread produced from the mixing of iron-folic acid and wheat flour can go a long way in helping to alleviate the problem.

5.2 Recommendation

From the point of sensory analysis and mixing operating conditions in the production of iron-folic acid mixing with flour, recommendations forwarded are:

- ❖ Some of the panelists commented that some of the products that have not sugar is not tasty so addition of 6% of sugar is recommended.
- ❖ Though the products were well liked by the panelists, most of them commented that recommended additives such as colorants, flavors and sweeteners need to be added especially to compete with the commercially available fortified bread.
- ❖ Effect of mixing ratio and operating conditions on nutritional value, protein and starch digestibility and shelf life of products as well as its effect on anti-nutritional components need to be conducted.
- ❖ There should be awareness creation on the health benefit of using the relatively cheap food products like iron- folic acid and wheat flour mixing products to the community with health programs to the developing countries worldwide to compensate iron and folic acid deficiency in the diet of pregnant women.

Fortification processing has become the standard operating system in most food industries. So this way of processing foods from cereals should be promoted in countries where people cannot afford unfortified flour with relatively lower cost, for vegan people and for people who have medical recommendation not to consume unfortified flour due to health problem as well as for gluten intolerants.

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ISO 22000:2018 food safety management system/Africa privet limited company

Federal democratic republic of Ethiopia ministry of trade and industry *Flour & bakery technology training programmer*

APPENDICES

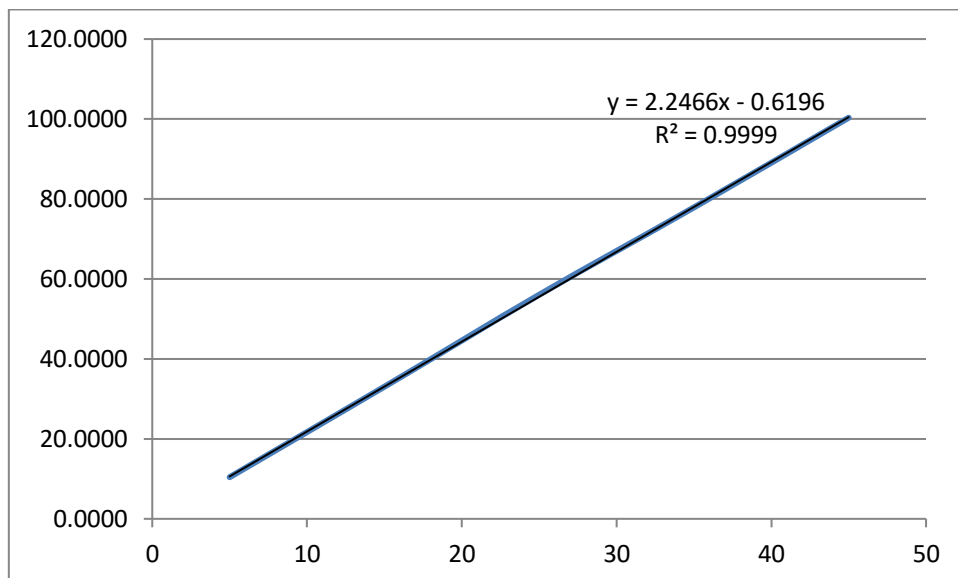


Figure 1: Calibration curve of micro feeder with premix

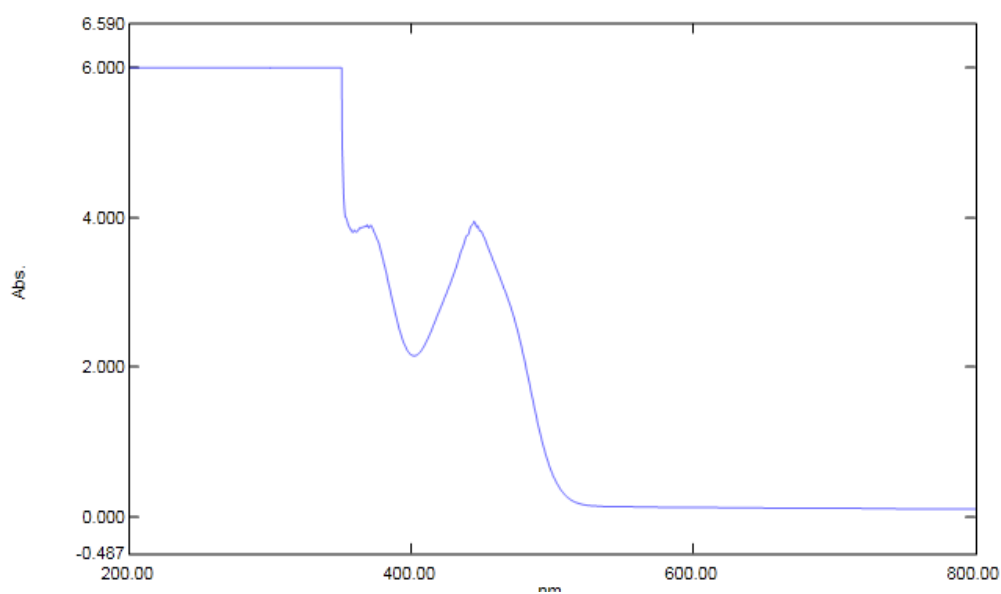


Figure 2: UV result of folic acid standard at 50ml distilled water

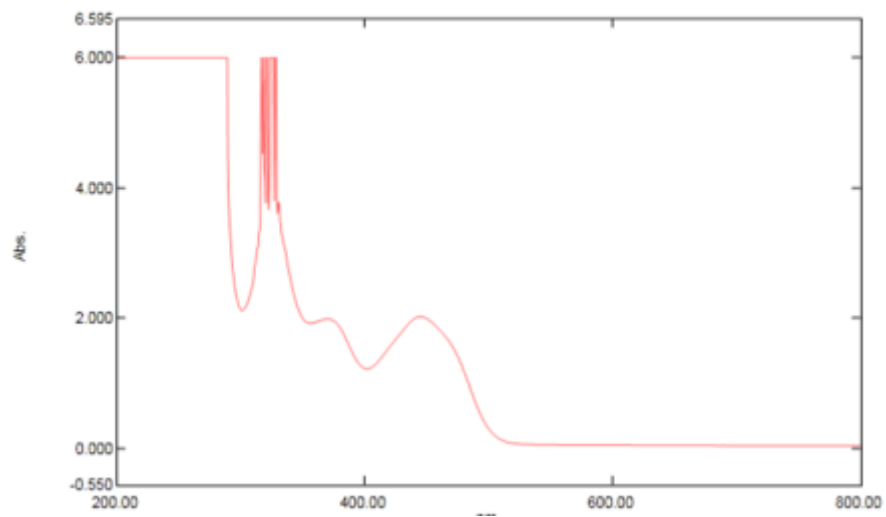


Figure 3: UV result of folic acid standard at 100ml distilled water

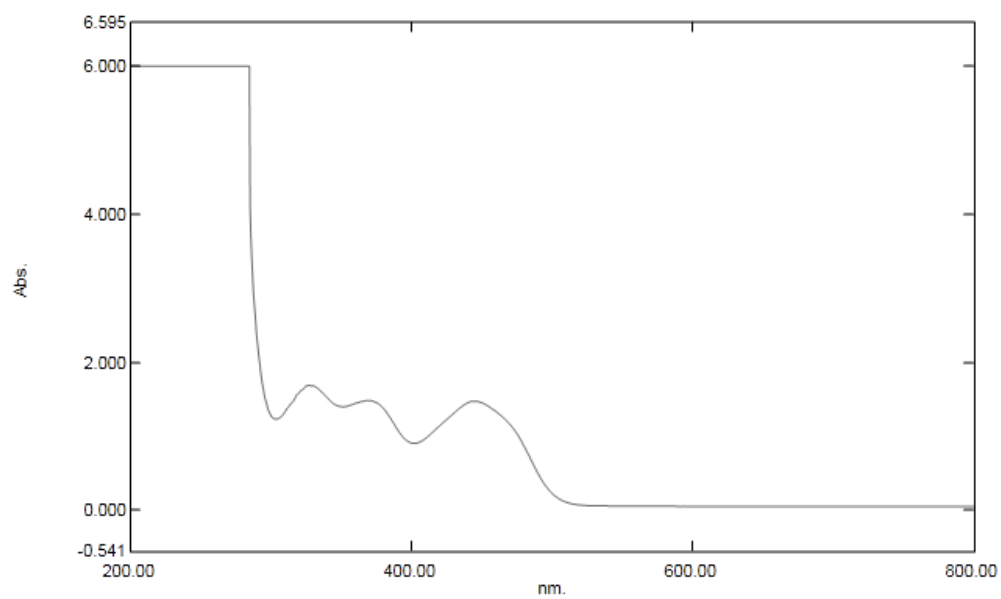


Figure 4: UV result of folic acid standard at 150ml distilled water

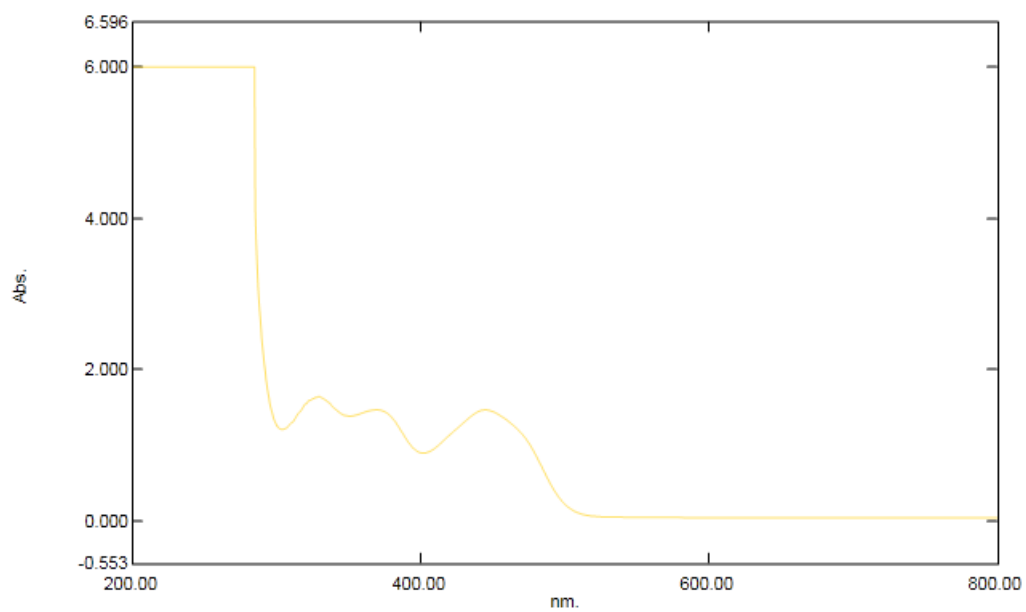


Figure 5: UV result of folic acid standard at 175ml distilled water

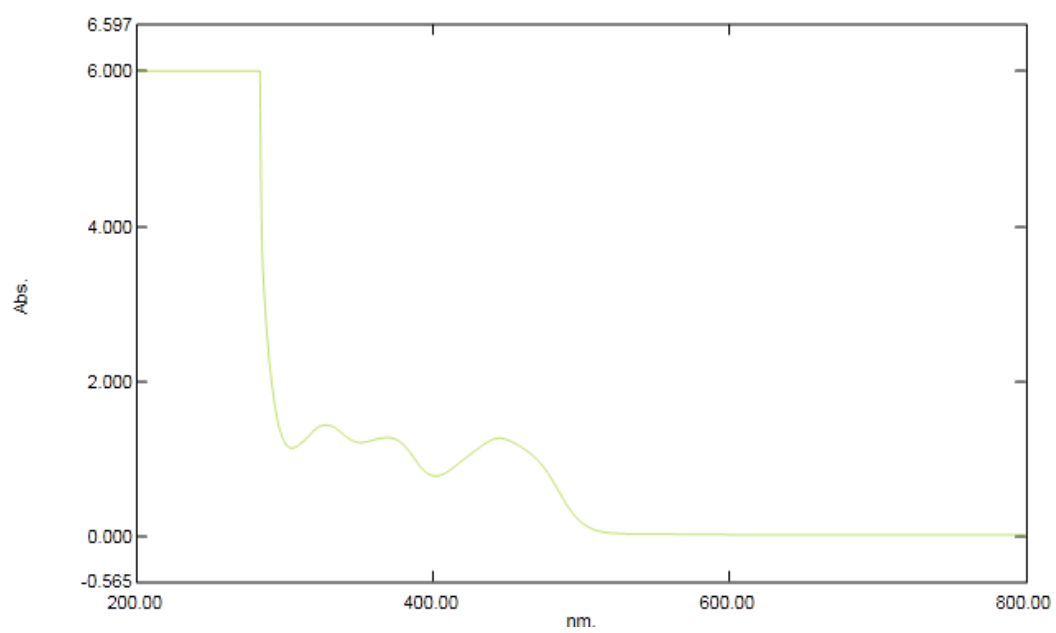


Figure 6: UV result of folic acid standard at 200ml distilled water

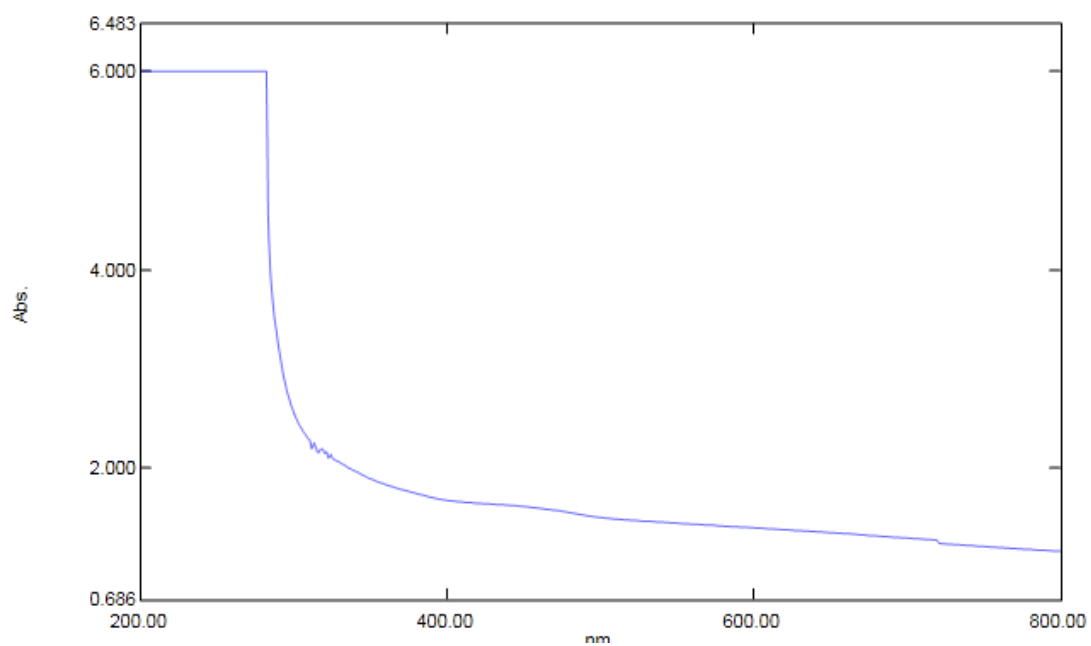


Figure 7: UV result of folic acid fortified bread after 30 minute observation

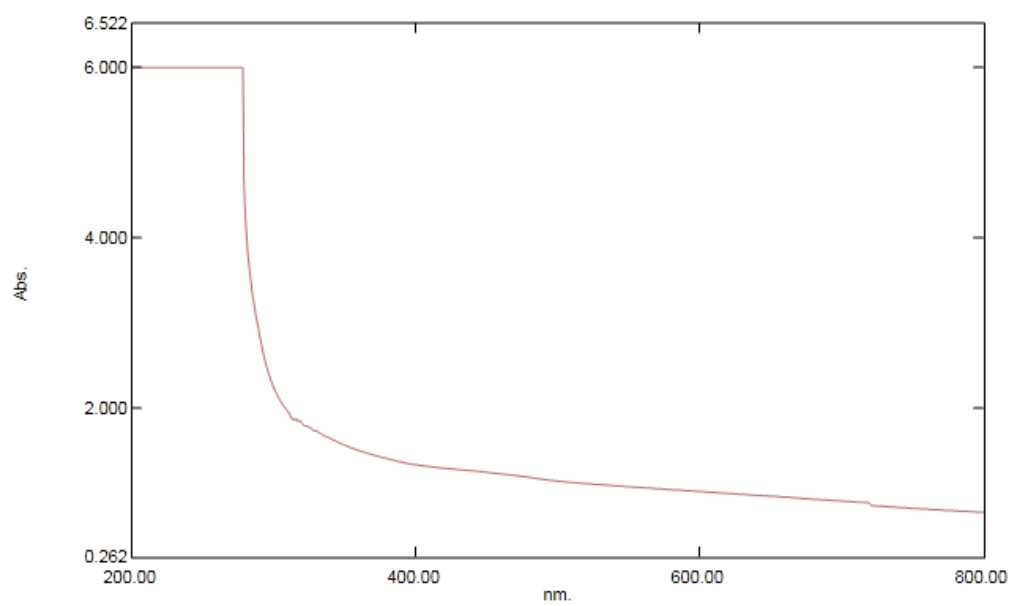


Figure 8: UV result of folic acid fortified bread after 60 minute observation

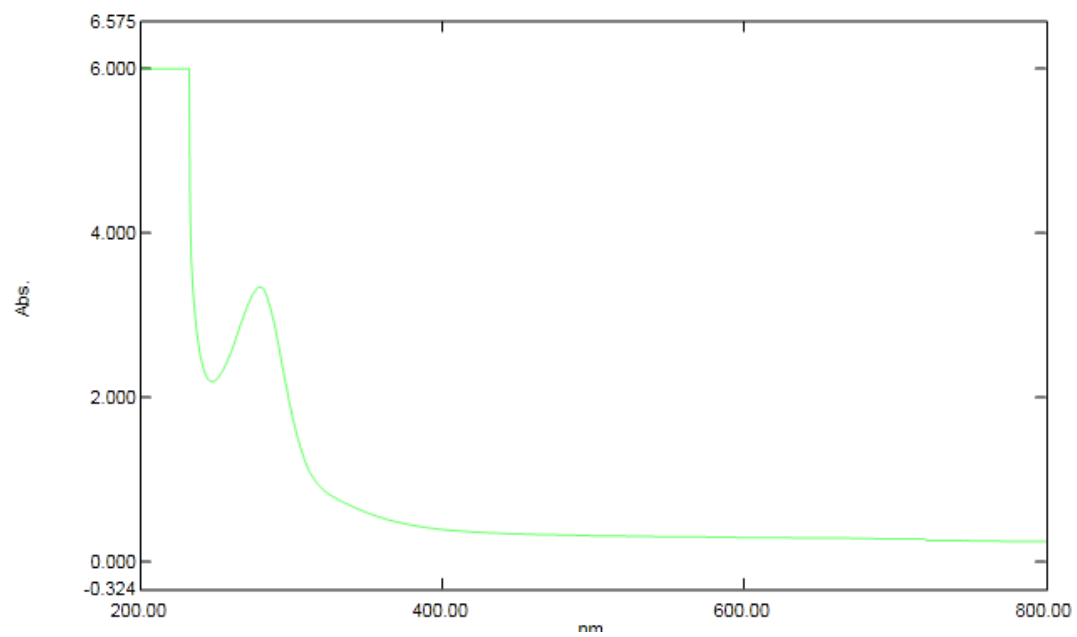


Figure 9: UV result of folic acid fortified bread after 120 minute observation

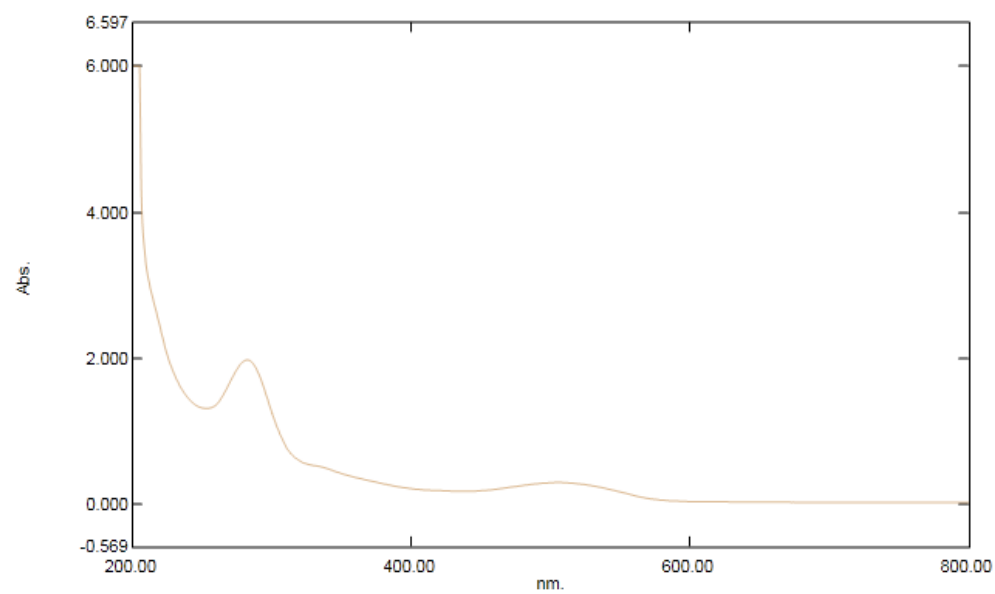


Figure 10: UV result of iron standard at 50ml distilled water

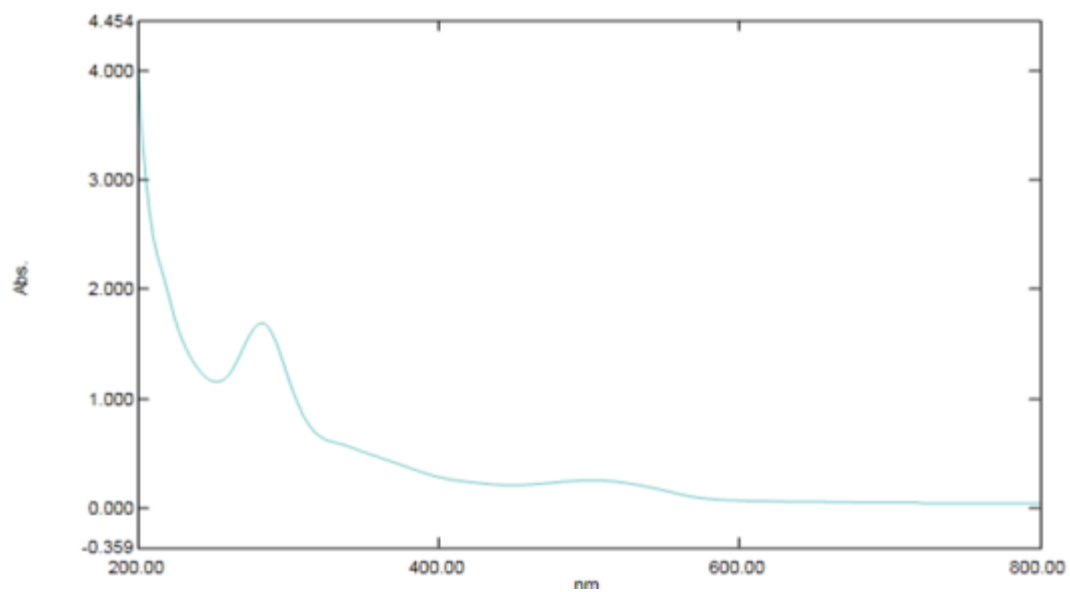


Figure 11: UV result of iron standard at 70ml distilled water

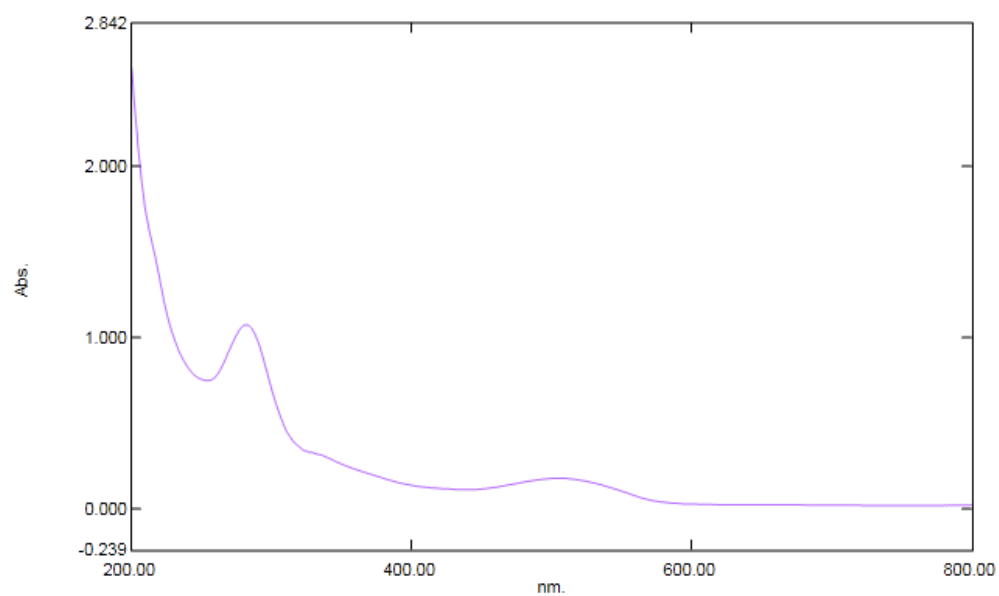


Figure 12: UV result of iron standard at 100ml distilled water

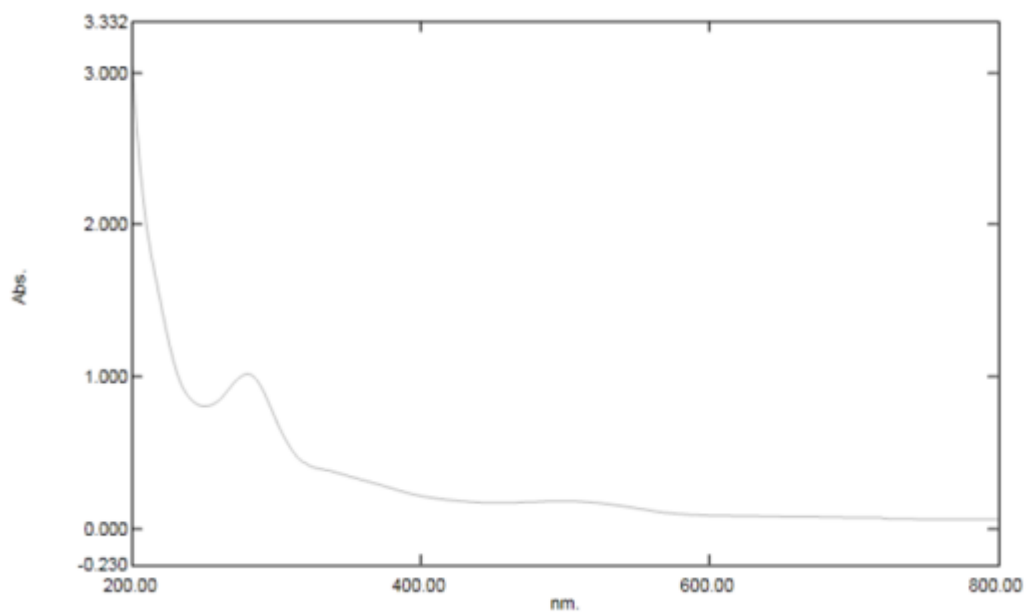


Figure 13: UV result of iron standard at 120ml distilled water

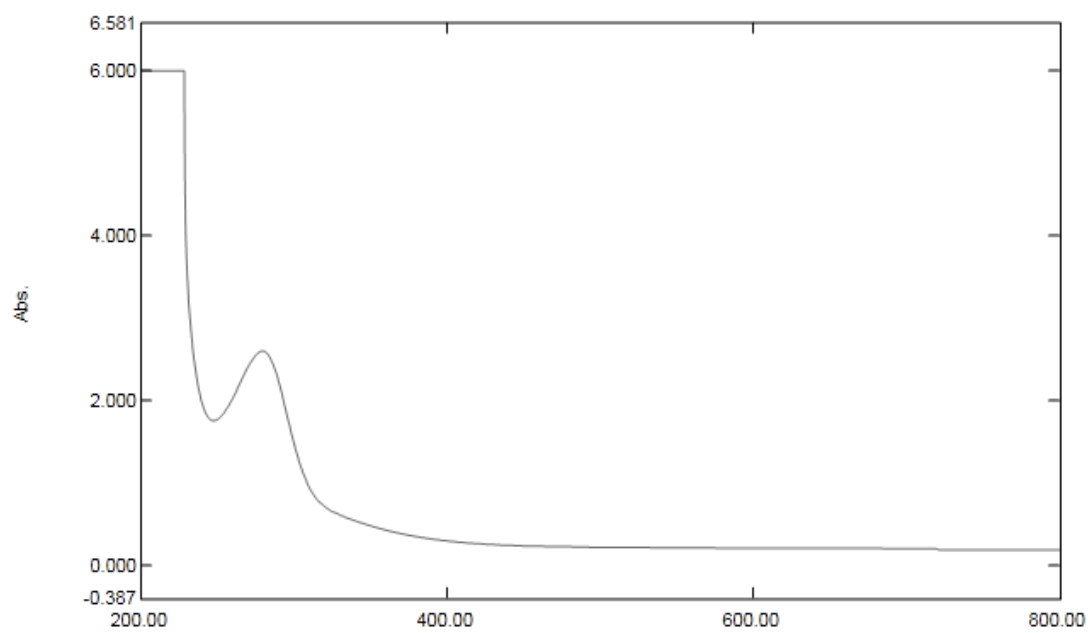


Figure 14: UV result of iron fortified bread after 30 minute observation

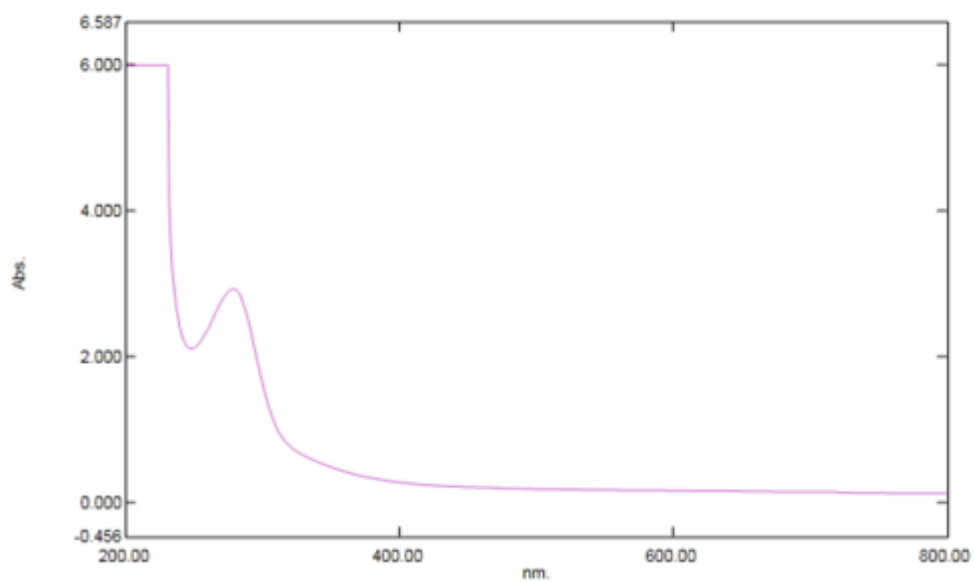


Figure 15: UV result of iron fortified bread after 60 minute observation

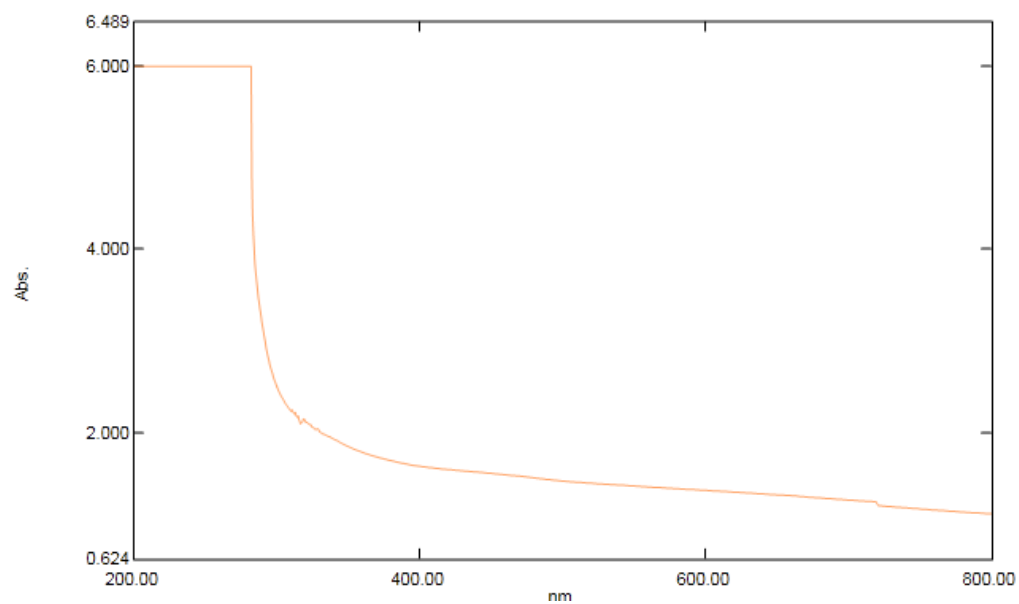


Figure 16: UV result of iron fortified bread after 120 minute observation



Figure 17: Preteens 9500 analyzer

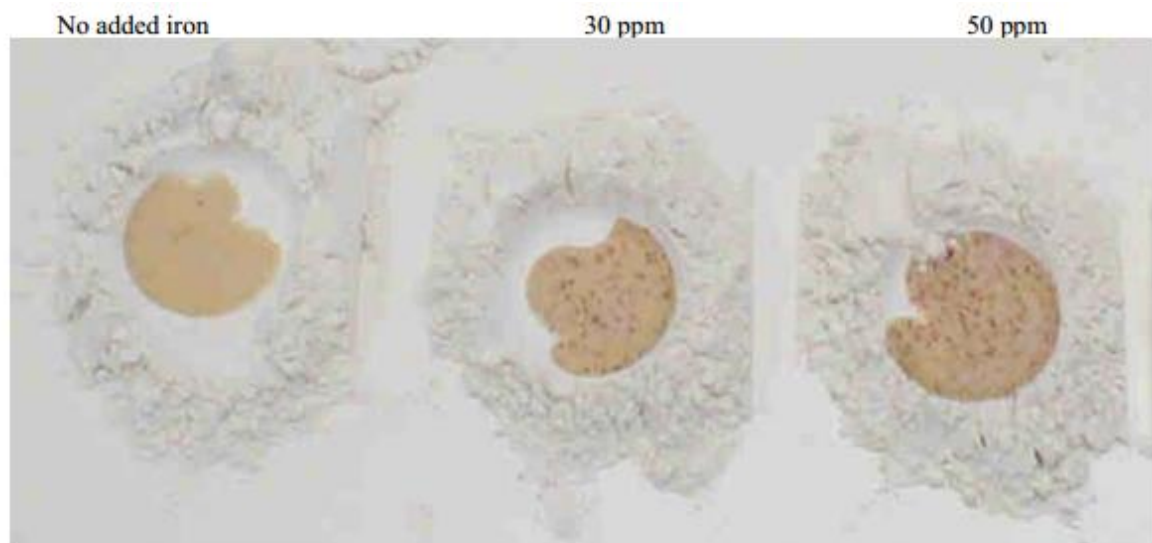


Figure 18 Example of iron spot test on flour with different levels of added iron



Figure 19 picture of bread preparation



Figure 20 picture of folic acid, fortified bread and unfortified flour



Figure 21 experimental picture of iron fortified bread and folic acid fortified bread

