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CHEMICAL AND PHYSICAL PROPERTIES OF THE FORTIFIED WHEAT FLOUR WITH SYNTHETIC FeNaEDTA COMPLEX

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ABSTRACT

This study includes fortification of two type of flour 70 and 80 % extraction with two sources of non-haem iron sodium iron EDTA (FeNaEDTA) which was synthesis in laboratory and ferrous sulfate in level of 30 mg iron/kg flour. The synthesis FeNaEDTA has been identified in several methods, infra red spectrophotometry, C.H.N analyzer and inductively coupled plasma optical emission spectrometry (ICP- OES). NaFeEDTA is the only non-haem source that has good bioavailability as it is relatively independent of flour composition and withstands the inhibitory effects of phytates.
Chemical analysis of the two type of the flour before and after fortification with FeNaEDTA was done (moisture, ash , protein , fat and wet gluten)% and the amount of iron as mg/100g.The falling number was not affected by the above fortificants.The values of falling Number of 70% extraction for non-fortified and fortified flour by FeNaEDTA and ferrous sulfate were (425,426,427) second respectively, while for 80% extracted flour were (445,446,448) second respectively.
The color test showed an increasing of color degree upon fortified by iron sulfate and decreasing of upon fortified by FeNaEDTA in both type of flour.

Keywords: Fortified Flour, FeNaEDTA

INTRODUCTION

The fortification is one of most important expression used in FAO and WHO, which mean that in the practice of deliberately increasing the content of an essential micronutrient, i.e. vitamins and minerals in a food, so as to improve the nutritional value of the food supply and provide a public health benefit with minimal risk to health **(Lindsay *et al.*, 2006)**.
It was employ several sources of food for fortification with iron, such as cereals flour, salt and sugar for the general people, whereas other food was target to specifying age group, like the fortified milk with iron for the newborn to reduced prevalence anemia iron efficiency **(Dallman, 1990)**.
The fortified flour with iron made a promise general strategic in the industrial country, the glance force to the fortification of flour with iron be established by consumption rich food with animating absorption of iron, like meat and citrus fruit, these foods helped the industrial country to drop the anemia deficiency of iron concretely **(Hurrell and Jacobs, 1996)**.
The requirement of human to the iron was differ according to the age, sex and situation of health, so the FAO and WHO were advise to getting 2-10 mg Fe/day for the baby up to 12 years and 13-19 mg Fe/day for the adolescent and 12-28 mg Fe/day adolescent and adult women and 5-9 mg Fe/day for the man and women at menopause**(FAO/WHO, 2002)**.
Technically, iron is the most challenging micronutrient to add to foods, because the iron compounds that have the best bioavailability tend to be those that interact most strongly with food constituents to produce undesirable organoleptic changes such as the appearance or taste of foods. The two principal groups of iron compounds are haem iron compounds and non-haem iron compounds depending upon their sources, haem iron compounds are a by-product of bovine slaughter-houses which is a very attractive fortificant of foods of vegetable origin.Inhibitors of non-haem iron compounds in vegetable foods do not interfere with fortification of haem iron.However, haem iron affect the fortified product organoleptically and not suitable for fortification of many products. A successful fortification application has been the chilean bovine-haemoglobin-fortified cookies program**(Walter,1993)**. The complex compound FeNaEDTA is consider to be one of non-haem iron compounds that characterized as a stable during manufacturing and storage, so this compound performed to contain the iron in depression level pH circumstance (PH=2) in the stomach to prevent it to combine with phytic acid which is the most one of the inhibitors to iron absorption in the body **(Hurrell *et al.*, 2004)**.

In high-phytate foods, the absorption of iron from NaFeEDTA is 2–3 times greater than that from either ferrous sulfate or ferrous fumarate. In foods with low phytate content, however, iron absorption is similar, in addition to better absorption from high-phytate fortified foods like wheat flour, NaFeEDTA offers other advantages, it does not promote lipid oxidation in stored cereals **(Hurrell et al., 2000)**.
The Joint FAO/WHO Expert Committee on Food Additives has approved the use of FeNaEDTA at 0.2 mg Fe/kg body weight per day **(WHO, 2000)**.According to there is no existence local studying in Iraq about the fortified wheat flour with iron as FeNaEDTA form, so the present study aimed to synthesis and identify the FeNaEDTA complex by IR spectroscopy, C.H.N. analyzer and Inductively Coupled Plasma-OES and fortifying the wheat flour with this compound.

MATERIAL AND METHODS

Preparation of solutions

A series of solutions for iron concentrations 1,2, 3, 4, and 5 part per million were prepared by dilution from a stock solution 1000 ppm iron for deterimination iron in wheat flour by flame atomic absorption. 0.01% (w/v) FeNaEDTA complex solution was prepared for determination the amount of iron in the complex by ICP-OES instrument and 0.1M KSCN solution used for detection of free iron ions.

Synthesis of the complex FeNaEDTA

The complex FeNaEDTA was synthesised in the laboratory according to the method of **Layriss and Martinez, (1977)** and **Cranton, (1989)** with some modifications as shown in the Figure (1). The free iron ions were detected by dissolving 0.2 g of complex in 2 ml of deionized water in the test tube by adding some drops of 0.1 M KSCN solution, when red bloody color appeared in the solution, this is a sign for present free iron ions in the complex, otherwise it must be purified from these impurities by the re-crystallization. The complex was re-crystallized by adding ethanol (99.7%) to the aqueous solution of the complex to precipitate it.

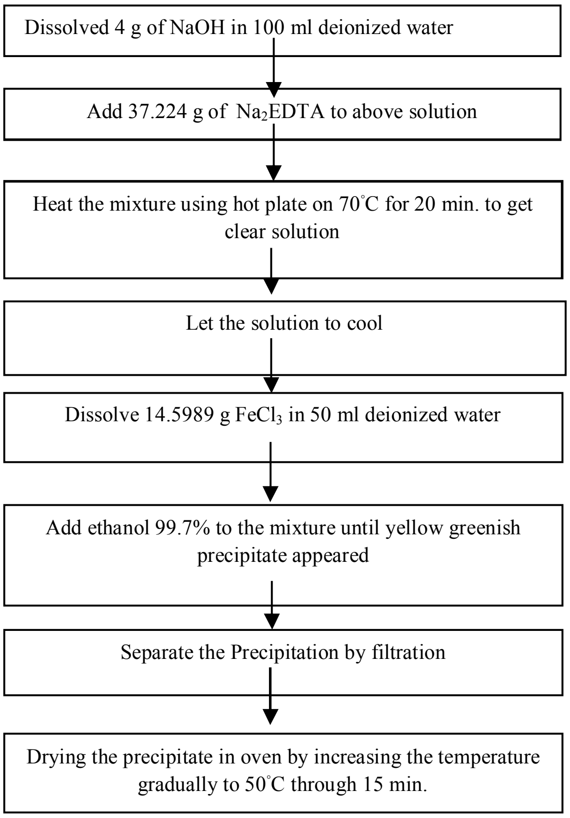


Figure 1 Synthesis method of FeNaEDTA complex in laboratory

Identification of the complex FeNaEDTA

Three techniques used for the identification of complex FeNaEDTA, infrared spectroscopy (IR), the infrared instrument manufactured by SHIMADZU Japanese in the laboratory of State Company for Petrochemical Industries in Basrah/Iraq by using KBr disc and analysis by (C.H.N) equipped company Varian U.S. and inductively coupled plasma optical emission spectrometry (ICP-OES), both in the laboratories of the Department of Chemistry, College of Science, university education teacher for Graduate Studies / Tehran / Islamic Republic of Iran.

Wheat Flour

Two type of flour, extracting 70 and 80% of the production mill Al-Rushed (Basrah) were milled for fortification with iron and stored in bags of polyethylene under temperature (-15 ° C) until used them.

Fortification of the Flour materials

The characteristics of fortificant materials Such as FeNaEDTA and ferrous sulphate which used in fortification are shown in Table (1).

Fortification method of wheat flour

The process of fortification was followed the method **Annie and Peter (2004)**, using a nutrient (Feeder) equipped from the company Brabender Canadian and the level of addition fortificants was 30 ppm for both kinds of flour based on the standard Iraqi No. 37 of 1988 and the referring **(Hurrell, 2007)**.

Table 1 characteristics of the materials used in the process of fortification the flour

Material	Chemical Formula	Molecular Weight	Color	% Iron	Source
FeNaEDTA Complex	$C_{10}H_{12}FeN_2NaO_8.3H_2O$	421.10	Yellow brownish	13.1	Prepared by our present work
Ferrous Sulphate	$FeSO_4$	151.91	White greenish	36	Evan Medical England

Chemical and physical wheat flour

The percentage of the moisture in the two kinds of flour was estimated by HG 53 Halogen Moisture Analyzer equipped from the company Mettler, Switzerland, the percentage of nitrogen in the flour by micro kjeldhal using the method **(11-46) AACC (1976)** and then multiply the result by 5.7 to get the percentage of protein, the percentage of ash content by the method **(10-08) AACC (1976)**, as well as using the instrument equipped from Inframatic Perten company of German to follow the instructions of the instrument manual and the percentage of fat by method **(048-7) AOAC (1984)** by using the Soxhlet with hexane solvent.

Determination amount of iron in the wheat flour

The amount of iron in wheat flour was determined according to the method **Davidson and Miller (2005)**, by ashing 2 g of the wheat flour in porcelain dish at temperature 550° C for 12 hours after that the ash residual was dissolved by adding 20 ml of 2 N hydrochloric acid and then diluted to volume of 100 ml with deionized water and finally the solution was measured directly in the flame atomic absorption Spectroscopy.

Determination of wet gluten

The wet gluten was determined according to the method **(38-12A) AACC (2000)**, by using a Glutomatic System supplier of company Perten Instrument Swedish, which has a self mechanical washing system for gluten by weighing 10 grams of flour and then multiply the result by 10 to get the percentage of wet gluten.

Determination color of wheat flour

The color of wheat flour was measured by the color measuring instrument supplied by the German company OKRIM by adding 50 ml of distilled water to 30 g flour and shaking the mixture then the emulsion was placed in the instrument cell , the unit of color is Kent-Jones.

RESULTS AND DISCUSSION

Identification of complex FeNaEDTA

Elemental analysis

Elemental analysis of the theoretical and experimental percentages of the elements carbon, hydrogen and nitrogen (C.H.N) of the complex FeNaEDTA was done, and the results are listed in Table (2).

Table 2 analysis of the elements of C.H.N.

Formula weight	C%		H%		N%	
	Theor.	Exp.	Theor.	Exp.	Theor.	Exp.
$C_{10}H_{12}FeN_2NaO_8.3H_2O$	28.49	28.61	4.27	4.17	6.64	6.59

Infrared spectra of the complex FeNaEDTA

Figure (2) shows the infrared spectra recorded for the synthesised complex in this study, it was appeared two strong bands in the region 3500-3300 cm^{-1} attributed to streching vibration of the bond (O - H) of water molecules associated with complex, and strong broad band at 1650 cm^{-1} attributed to the streching vibration of the bond (C = O), and the appearance of a very strong band at 1390 cm^{-1} was due to the streching vibration of the bond (C - N), and also the appearance of strong band at 1100cm^{-1} was due to the streching vibration of the bond (C - O). **Frank and Rogers (1966)** were pointed that the streching vibration of the bond (Fe - N) is located at 219 cm^{-1} and this is beyond the frequency of the instrument, *i.e.* below 400 cm^{-1}. Table (3) shows the most important bands that appear in the infrared spectra of the complex FeNaEDTA.

Table 3 The most important bands of the complex FeNaEDTA.

Band	wave number cm^{-1}
Streching vibration band O – H	3500-3300
Streching vibration band C = O	1650
Streching vibration band C – N	1390
Streching vibration band C – O	1100

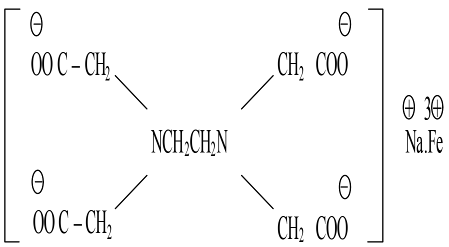
Determination of iron in the complex FeNaEDTA

The results of analysis of iron in the complex by inductively coupled optical emission spectrometry (ICP - OES) are shown in the table (4) which are includs the percentages of theoretical and practical of iron in the complex.

Table 4 Analysis of Iron in the complex by ICP-OES

Chemical formula	Fe%	
	Theoretical	Experimental
$C_{10}H_{12}FeN_2NaO_8.3H_2O$	13.26	13.18

The practical percentage of iron was (13.18%) which is within the limits required for the amount of iron in the complex as indicated in the specification prepared by JECFA, which is stipulates the amount of iron in this complex should not be less than 12.5% and not more than 13.5%. The complex FeNaEDTA are characterize by good solubility in water and in the form of powder with a greenish yellow color and with the amount of iron (13.1%) all these qualities in line with what the Dr. Paul Lahomann said in **(Most, 2000).** Through the process of identification of the complex in the above it become clear that the chemical structure of the complex is as follows:



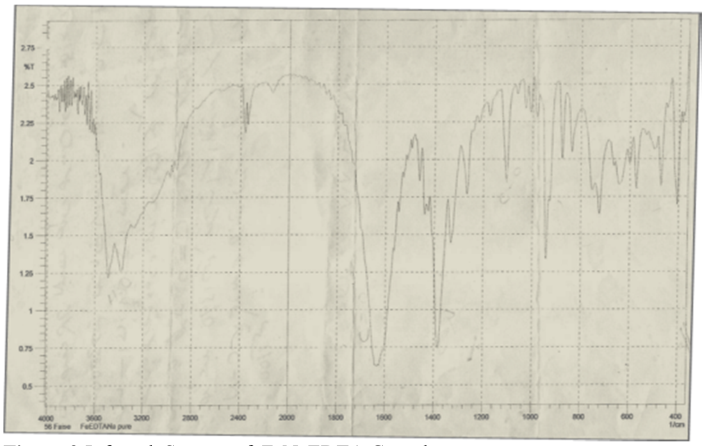


Figure 2 Infrared Spectra of FeNaEDTA Complex

Chemical analysis of the flour

Table (5) shows the chemical compositions of flour extraction 70% which were divided into three groups, (T_0) containing 11 mg iron / kg flour, fortified flour with FeNaEDTA (T_1) containing 40 mg iron / kg flour and with ferrous sulfate $FeSO_4$ (T_{11}) containing 40 mg iron / kg flour, and also the chemical compositions of flour extraction 80% which were also divided into three groups, non fortified (T00) containing 22 mg iron / kg flour, fortified flour with FeNaEDTA (T2) containing 49 mg iron / kg flour and with ferrous sulfate (T22) containing 50 mg iron / kg flour, the results of statistical analysis were appeared no significant effect of fortificants on moisture content on both type flour 70% and 80% extraction. The effect of fortificants was found to be significant on the ash content of both type of fortified flours. The treatment T0 and T00 (unfortified wheat flour) contain minimum ash content because of absence of any type of the fortificant. The presence of higher ash in fortified flour might be attributed to the addition of fortificants. The protein and fat content was found to be significantly the higher in non fortified 80% extraction than 70% extraction, it may be due to higher bran protein and fat in 80% extraction flour. No significant effect of fortificants was observed on protein and fat for both type wheat flour and these are consistent with what found **(Akhtar, 2005)**. The amount of iron in non fortified of both types of flour were 1.1 and 2.2 mg / 100 g, respectively. The effect of fortificants was found to be non significant on wet gluten for both type wheat flour 70% and 80% extraction and these are consistent with what found **Mihai (2004)**. The effect of fortificants was found to be non significant on falling number for both type wheat flour 70% and 80% extraction.

Table 5 chemical analysis of non fortified and fortified flour samples with FeNaEDTA and ferrous sulphate (%)

Treatment	Moisture%	Ash%	Protein%	Fat%	carbohydrate%	Iron mg/ 100 g	Wet gluten %	falling number(Second)
T_0	13.99	0.56	10.2	0.86	74.39	1.1	29.5	426
T_1	13.89	0.63	10.5	0.84	74.14	4.0	29.6	426
T_{11}	13.95	0.63	10.4	0.85	74.14	4.0	29.7	427
T_{00}	13.99	0.89	12.0	1.59	71.53	2.2	28.0	445
T_2	13.85	1.04	11.90	1.57	71.64	4.9	28.0	446
T_{22}	13.94	1.04	11.98	1.58	71.46	5.0	28.1	448

The above values represent the average of three replicates
(T0) 70% extraction flour is non fortified (11mg iron / kg)
(T1) 70% extraction flour fortified with FeNaEDTA (30 mg iron / kg)
(T11) 70% extraction flour fortified with ferrous sulphate (30 mg iron / kg)
(T00) 80% extraction flour is non fortified (22 mg iron / kg)
(T2) 80% extraction flour fortified with FeNaEDTA (30 mg iron / kg)
(T22) 80% extraction flour fortified with ferrous sulphate (30 mg iron / kg)

Flour physical Tests

Test the color

Figures (3) and (4) are show the color degrees for flour extraction 70 and 80% of non fortified and fortified with ferrous sulfate and FeNaEDTA and the analysis results showed significant in color degrees for all treatments (T0, T1, T11) and (T00, T2, T22), the reason for the rise in the degree of color for both types of flour when fortified with ferrous sulfate may be due to increasing the amount of iron which leads to an increase in the percentage of ash and this result consistent with **Matsuo et al., (1982)**. The reason for the low degree of color for both types of flour when fortified with FeNaEDTA may be due to the adsorption of some natural dyes in flour.

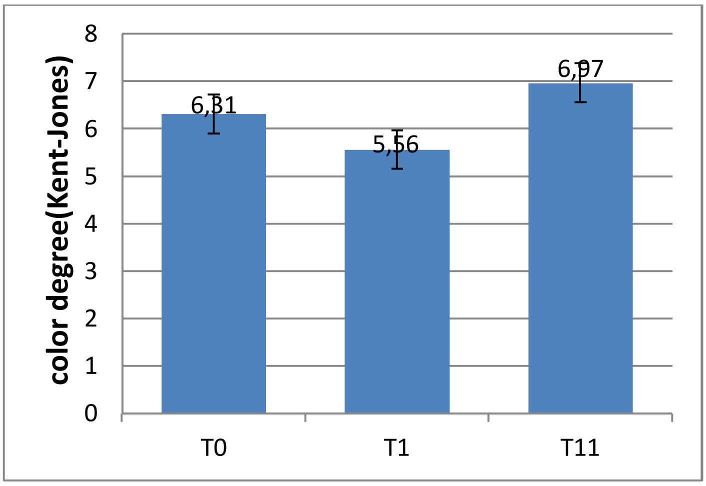


Figure 3 shows the color degrees for flour extraction 70% of non fortified and fortified with ferrous sulfate and FeNaEDTA

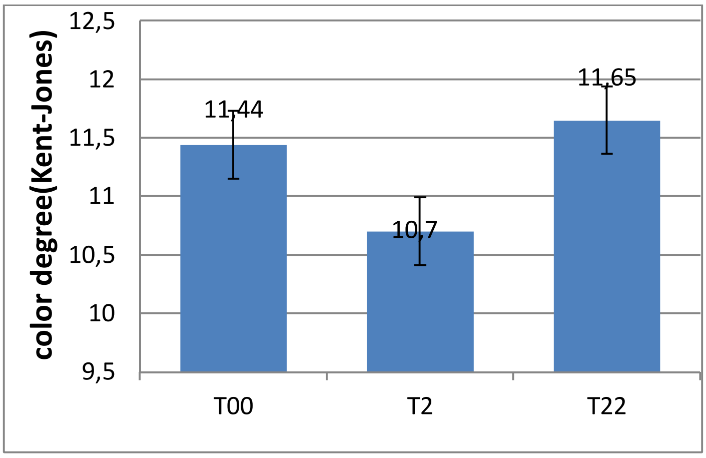


Figure 4 shows the color degrees for flour extraction 80% of non fortified and fortified with ferrous sulfate and FeNaEDTA

CONCLUSION

The best method to determine the amount of iron in the complex FeNaEDTA is by ICP-OES. It was found that the fortification with complex FeNaEDTA reduces the flour color either from the extraction Of 70% or 80% , on the contrary fortification with ferrous sulfate, which increases the flour color. Our following study is about the absorption of Iron from the complex FeNaEDTA as compare with ferrous sulfate by biological experiment on the rats and studying the effect of these materials on rheological properties of two kinds flour.

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