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Assessment of Iron Fortification Influence on Organoleptics and Physico-Chemical Properties of Yogurt

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Abstract: Innumerable percentage of the world population suffers from shortage of vitamins and minerals which is usually called malnutrition. Enough perception and access of such essential vitamins and minerals have close relationship with eternity, physical and mental developments, good health, general welfare of individuals and societies. In this research, the fortification of yogurt with iron has been studied. The kinds of iron used in this study include: $FeCl_3$ $(H_2O)_6$, The whey protein-chelated iron (Fe-WP) and The Fe-Casein complex (Fe-CN) that each of them were evaluated in three quantities (10, 20 and 40 milligrams per one kilogram of milk). Then their chemical experiments and organoleptic specifications were studied after keeping 21 days in refrigerator and their results were reported. Results showed that all of these iron compounds were suitable for yogurt but two complexes of iron, including Fe-WP and Fe-CN, were better to be used.

Keywords: Iron fortification, milk, yogurt

INTRODUCTION

Milk or other dairy products are close to ideal food that contains all nutrients required for newborns, adults and old people. Milk is considered as a good source of proteins, fat, carbohydrates as well as vitamins, calcium and phosphorus; however, it is generally poor source for trace elements [6]. Traces metals like zinc, manganese, copper and iron have special importance among milk constituents. Variations in milk composition occur due to various factors such as maternal trace elements, intake and status, maternal age, parity, residing area. This variability in essential elements could result in inadequate elemental nutrition of infants feeding on human milk. The use of fortified human milk produces adequate growth in premature infants and satisfies the specific nutritional requirements [11].

Yoghurt has gained widespread consumer acceptance. It is an excellent source of calcium and protein but as typical in all dairy products, it contains very little iron. Therefore, dairy products are logical means for iron fortification because they have high nutritive values, reach target population and are widely consumed [12-17]. Iron deficiency anemia remains an enormous global problem. Up to half of the children in developing countries and about 10% of the children in developed countries are estimated to be iron deficient. Iron deficiency leads to impaired physical work performance, cognitive impairment, and adverse pregnancy outcomes [9].

The quality of iron-fortification dairy products depends on the iron sources used, levels of iron and properties of dairy products utilized for iron fortification. Fortification with iron is technically

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more difficult than with other nutrients because iron reacts chemically with several food ingredients. Therefore, the ideal iron compound for food fortification should supply highly bioavailability iron, it should not affect the nutritional value or sensory properties of the food, it should be stable during food processing and finally it should have low cost [12-17].

It has been shown that fresh yoghurt fortified with iron from different sources seems to be slightly affected by iron concentration. In this respect, it was reported that the sensory quality of iron-fortified dairy foods has been shown to be affected by the type of iron used, the amount of iron added and the properties of dairy products being fortified [3-4].

Therefore, the purpose of this study was to identify potential iron fortification sources that would cause minimal sensory deterioration in yoghurt. The kinds of iron used in this group of nutritious materials including: $FeCl_3\ (H_2O)_6$, Fe-WP and Fe-CN that each of them were evaluated in three quantities (10, 20 and 40 milligrams per one kilogram of milk). Then their chemical experiments and organoleptic specifications were studied after keeping 21 days in refrigerator and their results were reported.

MATERIALS AND METHODS

Cow's milk (8.5 SNF and non fat) was provided and $FeCl_3(H_2O)_6$ was obtained from Merck chemical company, the Fe-Casein complex (Fe-CN) was prepared by adding 50 ml of 0.5 *M* $FeCl_3(H_2O)_6$ into 600 ml of skim milk and then precipitating the Fe-CN at pH 4.6 [14]. Whey protein-chelated iron (Fe-WP) was made by mixing 50 ml of 0.5 *M* $FeCl_3$ with 600 ml of acid (cottage cheese) whey and adjusting its pH to 3.5 to precipitate the complex [19].

The precipitates were centrifuged at 5000 rpm (Universal 320 model) for 10 min; washed once with 0.25% lactic acid solution and twice with double distilled, deionizer water; The precipitates were sieved in falcons and frozen in -20°C [7].

The iron content of Fe-CN was 0.97 ml g of Fe in 0.346 g of complex; and The iron content of Fe-WP was 7.46 ml g of Fe in 0.155 g of complex as determined by the atomic absorption spectroscopy system (ASS).

Yogurt Preparation

10 liter of non-fat milk was prepared and divided into 10 lots: 9 experimental lots that were fortified with iron to either 10, 20, and 40 mg of Fe kg^{-1} with either $FeCl_3(H_2O)_6$, Fe-CN, and Fe-WP solutions and a control lot that was unfortified. These mixtures were then heated to 82°C for 30 min. Each lot of mix was cooled to 42°C and inoculated with *S. thermophilus* and *lactobacillus bulgaricus* that were provided from Merck. The mixes were then packaged in containers and incubated at 42°C until they reached pH 4.3; the containers were then transferred to a cold room (4°C) for storage [7].

Chemical Analysis

Acidity measurement of yogurts was performed according of ISIRI standard number 2852. The pH of samples was done with pH-meter-thermometer-PHT 110 according of 2852 number of ISIRI. The SNF of samples were obtained according of 1753 number of ISIRI. Whey separation was measured by centrifugation method. The volume of supernatant was determined as synersis index and expressed in percent according to Abou El- nour et al (1). Fat content was measured according to 695 number of ISIRI.

Sensory Analysis

The presence of oxidized, metallic, or other off flavors in nonfat yogurts that had been fortified with iron in 10, 20, and 40 mg kg^{-1} was evaluated by a trained panel. The trained panel consisted of 10 judges who have skills in food science and were selected from a dairy factory. The taste panel evaluated the yogurts after 1, 7, 14 and 21 days storage at 4°C.

Yogurt samples were examined for flavor (10points), body and texture (5 points) and appearance and color (5 points) [5].

STATISTICAL ANALYSIS

All measurements were done in triplicate and used from (Repeated Measure) test. For all analyses were done Muchly's Test of Sphericity before Repeated Measure test. Results were analyzed with IBM SPSS 19 software.

RESULTS AND DISCUSSION

Chemical Analysis

The effect of iron salts fortification on acidity is shown in (Figure 1). The results showed that acidity increased in all samples during storage. Most changes of acidity were in control samples, $FeCl_3$ 40 ،$FeCl_3$ 20 ،Fe-CN 10 and Fe-WP 20. The acidity results of these samples had no significant difference with control sample ($p>0.05$). These results are in agreement with those reported by (Hekmat, McMahon, 1998) [8].

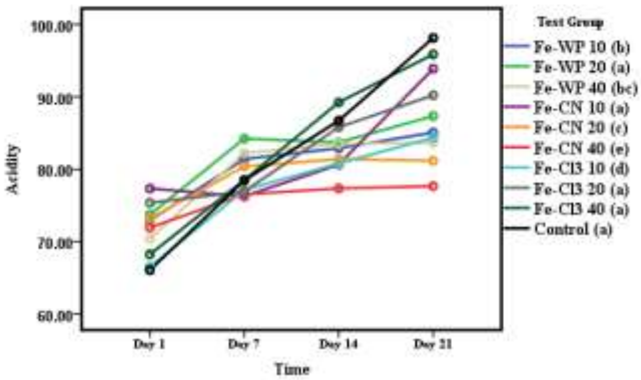

Figure 1. Effect of different iron salts on acidity of iron fortified yoghurt during storage period at 4± 2°C

Data presented in (Fig. 2) show the effect of iron salts fortification on pH. PH measurement monitors lactic acid production and aids in the quality control of yogurt's ingredients. The results showed that pH decreased in all samples during storage. Most changes of pH were in control sample and fewer changes were in Fe-WP 10, Fe-WP 40 and Fe-CN 10. These results are in agreement with those reported by (M. Elkholy, 2011) [5].

In fact fortification had no effect on the incubation time required for the yoghurt mixes to reach pH 4.3 and the starter culture growth was independent of iron fortification [5].

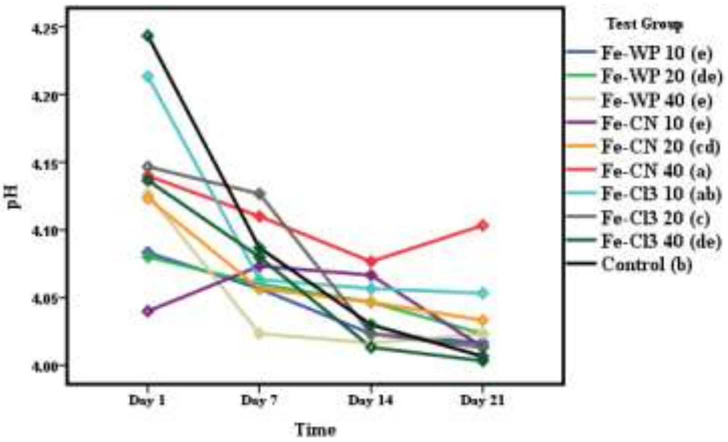

Figure 2. Effect of different iron salts on pH of iron fortified yoghurt during storage period at 4± 2°C

Figure 3 shows SNF content in samples. The total solids content of milk can be increased by concentration processes, such as, evaporation under vacuum, and membrane processing. The milk solids content (including the fat content) for yogurt ranges from around 9% for skim milk yogurt to more than 20% for certain types of concentrated yogurt. Many commercial yogurt products have milk solids contents of 14-15% [13]. The results showed that SNF increased in all samples during storage. (Mehanna and Gonc, 1988)[10] Mentioned similar trend and attributed these increase to evaporation of some yogurt water during cold storage.

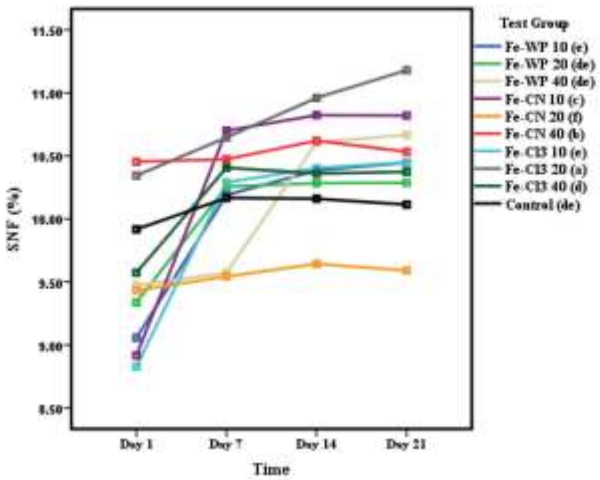

Figure 3. Effect of different iron salts on SNF of iron fortified yoghurt during storage period at 4± 2° C

Figure 4 shows the whey separated from yoghurt fortified by different iron salts. Synersis or spontaneous whey separation on the surface of set yogurt is regarded as a defect. This problem can be reduced or eliminated by increasing the level of milk solids to ˜15% [14]. Whey separation (wheying-off) is defined as the expulsion of whey from the network which then becomes visible as surface whey. Spontaneous whey separation is related to an unstable network, which can be due to an increase in the rearrangements of the gel matrix or it can be induced by damage to the weak gel network [16]. Results showed that synersis decreased in all samples during storage; as a result of improve the protein hydration of some of the free water. On the other hand, fortified yoghurt with iron improved the water holding capacity [5].

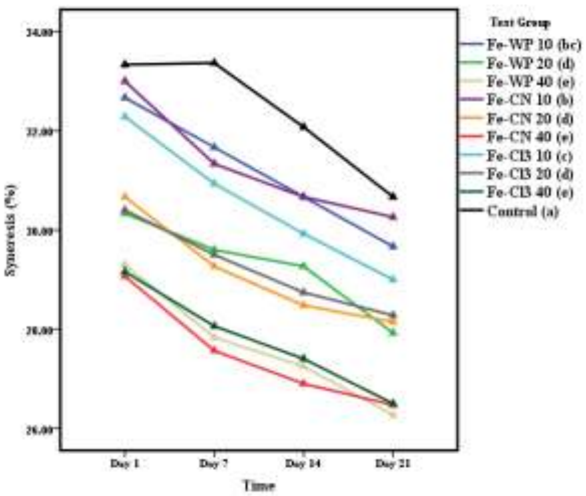

Figure 4. Effect of different iron salts on synersis of iron fortified yoghurt during storage period at 4± 2°C

Sensory Evaluation

Flavor shall possess a pleasant, clean acid flavor. It shall be free from undesirable flavors such as: bitter, rancid, oxidized, stale, yeasty and unclean [15].

The score of flavor for all yoghurt samples was stable up to 14 days then gradually decreased along the storage period. However the highest flavor score was for control and yoghurt fortified with Fe-WP, Fe-CN and $FeCl_3$ $(H_2O)_6$ with 10 ml g iron/kg of yogurt when fresh and during the storage time. These results (Fig. 5) are in agreement with those reported by (M. Elkholy, 2011)[5].

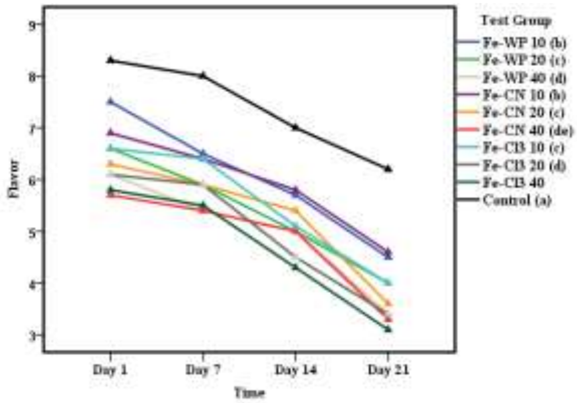

Figure 5. Effect of different iron salts on flavor of iron fortified yoghurt during storage period at 4± 2°C

Texture shall possess a firm, custard-like body with a smooth, homogeneous texture. A spoonful of yogurt should maintain its form without displaying sharp edges. Bulk flavoring ingredients should be uniformly distributed throughout the product [15]. In all iron treatments the body and the texture improved during storage, as a result of improve the protein hydration similar observation was reported by Augustin [2]. On the other hand, fortified yoghurt with iron improved the water holding capacity [Fig. 6].

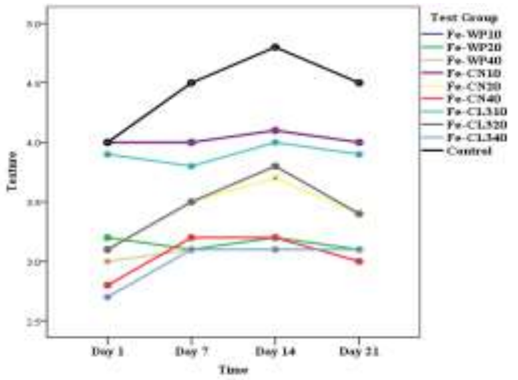

Figure 6. Effect of different iron salts on texture of iron fortified yoghurt during storage period at 4± 2°C

The score of color for all yoghurt samples decreased along the storage period (Fig. 7). However the highest color score was for control and yoghurt fortified with Fe-WP, Fe-CN and $FeCl_3$ $(H_2O)_6$ with 10 ml g iron/kg of yogurt when fresh and during the storage time. The lowest score of color was for $FeCl_3$ $(H_2O)_6$ in 40 ml g iron/kg of yogurt.

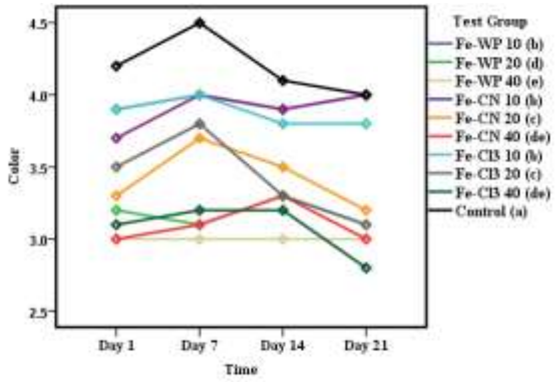

Figure 7. Effect of different iron salts on color of iron fortified yoghurt during storage period at 4± 2°C

The total score of yogurt fortified with iron was stable up to 14 days then gradually decreased along the storage period (Fig. 8). However the highest total score was for control and yogurt fortified with Fe-WP, Fe-CN and $FeCl_3$ with 10 ml g iron/kg of yogurt when fresh and during the storage time.

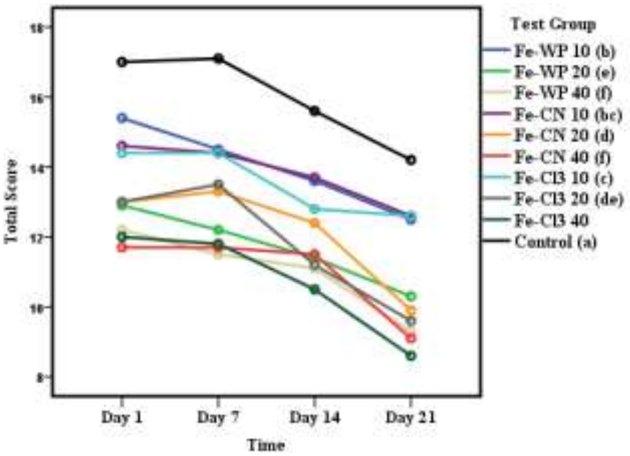

Figure 8. Effect of different iron salts on total score of iron fortified yoghurt during storage period at 4± 2°C

CONCLUSION

When the yogurts were judged by untrained panelists, both unfortified and fortified yogurts were equally liked. $FeCl_3$ $(H_2O)_6$, Fe-CN, and Fe-WP are all potential iron sources for the fortification of yogurt although use of a protein chelated iron may help to minimize production of any oxidized flavors. The yogurt fortified with Fe-CN and Fe-WP gave accepted yoghurt quality. The foregoing results suggest possibility of making good quality yoghurt by fortifying yoghurt milk with Fe-WP or Fe-CN or $FeCl_3$ $(H_2O)_6$ respectively at a level of 20 mg kg^{-1} milk.

A (120-g) cup of yogurt fortified with 20 mg of iron/kg of yogurt would provide approximately 15% of the US recommended daily allowance of iron for women, which is sufficient to allow the yogurt to be labeled as an iron-fortified food. In the US, a claim can be made for iron content if the product contains at least 10% of the daily value for iron [7].

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