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Iron fortification in kulfi

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Abstract
Kulfi was prepared from milk standardized to 2% fat and 9% MSNF. Iron fortified kulfi formulated to contain 30 ppm iron from external added iron salts (based on the approximate iron content and bioavailability of different sources of iron) was prepared using six iron salts viz., Ferrous gluconate (FG), Iron reduced (IR), Ferric chloride (FC), Ferric pyrophosphate (FP), Ammonium ferric citrate (FA) and Ferrous sulphate (FS). The experiment samples were compared with control (C). Fortification of kulfi with FA and FC did not significantly (P>0.05) affect the acidity, viscosity and meltdown time of the samples. From amongst the six types of iron sources only FA was found to be acceptable. The effect of level of addition of FA at different levels viz. 15, 30, 40 and 50 was studied. It was found that addition of iron at the highest level i.e. 50 ppm resulted in significant reduction in overall acceptability of the resultant product. In shelf life studies, it was found that fortification of iron @ 40 ppm resulted in significant reduction in flavour and overall acceptability scores after 30 days of storage whereas iron fortified samples @ 30 ppm remained acceptable up to 90 days of storage. Hence, it can be concluded that acceptable quality iron fortified kulfi can be prepared by addition of ferric ammonium citrate (30 ppm available iron) just before freezing of kulfi mix is acceptable up to 90 days at -18±2 °C.

Keywords: Iron fortification, kulfi

Introduction
It is well known that iron deficiency (anemia) is still the most prevalent nutritional problem in the world. Calcium and iron are two nutrients that are essential for growth. Both are also needed in higher amounts by women, especially because of increased requirements during pregnancy and because of their higher risk for osteoporosis and iron-deficiency anemia. Dairy products contribute many nutrients to the diet (calcium, riboflavin, protein, magnesium, and vitamins A, B6, and B12) but provide very little iron (0.6 mg of iron/kg of milk). Fortification of dairy products with iron has thus been frequently considered as a potential means for preventing iron deficiency. Compatible and non reactive iron compounds are needed for fortification of foods as they have less of an 'iron taste' compared to soluble iron (Anon, 2003). There is a paucity of information on iron fortified frozen dairy products.

Kulfi is very popular in our country even amongst lower income groups. Halwais and small scale manufacturers usually prepare kulfi. Several research workers have described procedures for manufacture of kulfi (Salooja and Balachandran, 1982, Ghosdekar and Rao 1982, Ashokraju *et al*. 1988, Rajor and Vani 1991, Ramachandran *et al*., 2005) [11, 5, 2, 9, 10]. Kulfi is characterized by its slightly whitish to brownish appearance, compact and smooth to sometimes coarse texture and nutty, caramel flavour. In the traditional process, cow, buffalo or mixed milk is concentrated in a large pan over the fire. The concentrated milk is then cooled, sugar is added and the blend is thoroughly stirred. Sometimes, a small quantity of khoa is added during boiling. After adding nuts and saffron the mixture is filled in aluminum or plastic cones leaving about 5% headspace. The lids are put on and sealed with wheat flour dough. After sealing, the cones are immersed in ice-salt mixture (4:1 w/w) in an earthenware pot (*MATKA*) for freezing (Aneja *et al*., 2002) [1]. Problems associated with iron fortification such as development of oxidative rancidity will be lessened or minimum due to the low temperature of storage of the product. Hence, Kulfi was selected as a product for iron fortification. The study was conducted with to select a suitable source of iron and to select the level of iron fortification compounds which will be acceptable based on sensory analysis and give the most acceptable shelf-life and to study the shelf life of the fortified product.

Materials and methods

Kulfi was prepared from milk standardized to 2% fat and 9% MSNF. Sucrose was added @12% by weight of milk. The blend was concentrated tohalf its volume. Sodium alginate was added @ 0.2% by weight of milk at the final stages of concentration. The mix was cooled to 4±1 °C and aged overnight. Freshly ground cardamom (2 g/kg mix) was added before freezing. Iron fortified kulfi using different sources of iron were also prepared using the same method as described above. The iron salts were added after concentration in the hot mix (at 85-90 °C) to ensure that it was properly blended. The mixes were formulated to contain 30 ppm available iron. To study the effect of stage of addition of iron, ferric ammonium citrate (@ 30 ppm available iron content) was added at different stages of manufacture i.e. before heating and before freezing. The effect of level of addition of ferric ammonium citrate was assessed by fortifying kulfi with different levels of ferric ammonium citrate (to give 0, 15, 30, 40 and 50 ppm available iron) before freezing. Shelf life studies of iron fortified kulfi were conducted in the last part of the study. Iron fortified Kulfi was prepared using ferric ammonium citrate @ 0, 15, 30 and 40 ppm. Ferric ammonium citrate was added after heating to the aged kulfi mix. The samples were evaluated at regular intervals of 0, 30, 60, 90 and 120 days to study the effect of fortification of iron on shelf life of kulfi.

Analysis

The fat, titratable acidity and total solids content of kulfi mixes were determined by the standard method as suggested in ISI Handbook (ISI Handbook of food analysis, 1989). The protein content of mixes were determined by Semi – Micro Kjeldahl method (ISO: 8968- 1 (2014), using Kjel-plus Digestion System (Model-KPS 006L, M/s. Pelican Instruments, Chennai) and Kjel-plus Semi-Automatic Distillation System (Model-Distil M, M/s. Pelican Instruments, Chennai). As per this method the total nitrogen was determined and the value so obtained was multiplied by a standard factor 6.24 to get the protein content. Ash content of processed bottle gourd forms were determined by procedure described in Indian Standards (SP: 18 Part XI – Dairy Products). Total carbohydrate content was calculated on difference basis from total solid content.

Sensory Analysis

All the products (-18±2 °C) were evaluated by a panel of 10 judges for its sensory characteristics using a 9-point hedonic scorecard (Stone and Sidel, 2004). The product was subjected to the sensory evaluation by semi expert trained panel of ten judges for colour and appearance, body and texture, melting quality, flavour and overall acceptability criteria. Kulfi samples were tempered to -12±2 °C for 1-2 h before judging. The fresh and stored samples were tempered to -12±2 ^{0}C. The samples were labelled with random 3 digit codes. The order of presentation of samples was randomized across judges.

Statistical analysis

All experiments were in triplicate. Mean scores obtained for the experimental samples were compared with those of the control samples and the results were analyzed statistically for test of significance according statistical method of one way-ANOVA and mean ± SE as per the procedure given by Steele and Torrie (1980). Critical difference was determined at the 5% significance level.

Results and discussion

Iron fortified kulfi was prepared using six iron salts viz., Ferrous gluconate (FG), Iron reduced (IR), Ferric chloride (FC), Ferric pyrophosphate (FP), Ammonium ferric citrate (FA) and Ferrous sulphate (FS). The mixes were formulated to contain 15 ppm iron from external added iron salts based on the approximate iron content and bioavailability of different sources of iron All the experimental samples were compared with control (C) containing no external iron source. The average chemical composition of kulfi mix was Total solids: 42.5%, fat: 3.5%, protein: 5.6%, sucrose: 21.5% and ash: 1.31%. Addition of iron in any form did not influence the body and texture and melting resistance of the products. However, adverse effect on flavour was noticed when FG, FS, FP and IR were used as external sources for iron fortification. From amongst the six types of iron sources screened only FA and FC were found to be acceptable and used in the next part of study.

Iron fortified kulfi was prepared using FA and FC. The experiment samples were compared with control (C). Fortification of kulfi with FA and FC did not significantly (P>0.05) affect the acidity, viscosity and meltdown time of the samples (Table 1).

Table 1: Effect of iron fortification on selected physico-chemical properties of kulfi

Parameter	Type of kulfi			CD
	C	FA	FC	
Acidity (% lactic acid)	0.30	0.31	0.29	NS
Viscosity (cP at 4±2 °C)	258.3	263.2	268.4	NS
Meltdown time, min	35.5	36.5	36.3	NS

Each observation is mean of 6 replications

The average sensory scores of C, FA and FC are presented in Table 2. Addition of iron salts (FA and FC) had no significant (P>0.05) effect on colour and appearance, body and texture, melting quality scores of samples. However, the overall acceptability and flavour score of control and FA were found to be at par (P>0.05) with each other. Whereas, the overall acceptability score of FC was significantly (P<0.05) lower than control and FA. Samples containing FC were found to contain a slight metallic flavour and some very sensitive judges criticized it for chemical flavour and hence scored lower in flavour compared to control and FA.

Table 2: Effect of iron fortification on average sensory scores of kulfi

Parameter	Type of kulfi			CD
	C	FA	FC	
Colour and appearance	8.00	7.93	7.82	NS
Flavour	7.98a	7.83a	7.37b	0.17
Body and texture	7.99	7.88	7.63	NS
Melting quality	7.90	7.96	7.93	NS
Overall acceptability	7.90a	7.85a	7.48b	0.11

Each observation is mean of 6 replications; a–b Superscript letters following numbers in the same row denote significant difference (P<0.05)

From this part of the study FA was found to be the most suitable source for iron fortification in kulfi. The next part of the study was conducted to study the effect of stage of addition of iron on acceptability of kulfi. Kulfi was prepared by addition of FA to contain 15 ppm available iron at different stages of manufacture viz. before concentration and after concentration, before freezing. The effect of stage of

addition of iron source on sensory score of kulfi is presented in Table 3.

Table 3: Effect of stage of addition of iron salts on sensory scores (1-9) of iron fortified kulfi

Stage of Addition	Flavour	Body and texture	Colour and appearance	Melting quality	Overall acceptability
Control	8.27a	8.17	8.23 a	8.08	8.16 a
Before Freezing	8.03 a	7.92	7.78 a	7.96	8.02 a
Before Heating	4.12 b	7.88	6.42 b	7.91	4.71 b
CD (0.05)	2.526	NS	1.004	NS	2.481

Each observation is mean of 6 replications; a–b Superscript letters following numbers in the same row denote significant difference (P<0.05)

It can be seen in Table 3 that there all the sensory attributes of iron fortified samples viz. flavour, body and texture, colour and appearance and overall acceptability were at par (P>0.05) with control when the iron source was added before freezing. However, a significant reduction (P<0.05) in flavor, colour and appearance as well as overall acceptability score was observed when iron was added before heating. The samples developed strong metallic flavor and browning in colour was observed in such samples. Hence, in the next part of study iron was added before freezing.

In next part of the study, effect of level of addition of FA at different levels was studied and the result pertaining to sensory scores of such samples is presented in Table 4. It can be seen from Table 4 that addition of iron at the highest level i.e. 50 ppm resulted in significant reduction in overall acceptability of the resultant product.

Table 4: Effect of level of addition of iron source on sensory score of kulfi

Level of Addition	Flavour	B&T	C&A	MR	OA
Control	8.27a	8.17	8.23 a	8.06	8.16 a
15 ppm	8.03 a	8.04	7.78 a	7.96	8.02 a
30 ppm	7.58 a	7.98	7.44 a	7.88	7.48 a
40 ppm	6.92 a	7.84	7.21 a	7.86	6.96 a
50 ppm	4.22 b	7.68	6.92 b	7.83	4.71 b
CD (0.05)	2.314	NS	1.119	NS	2.228

Each observation is mean of 6 replications; a–b Superscript letters following numbers in the same row denote significant difference (P<0.05)

The shelf life of iron fortified kulfi was also determined by evaluating the samples at 0, 30, 60, 90 and 120 days of storage. The effect of concentration of iron on sensory attributes of kulfi during storage at -18+2 C is presented in Table 5. It can be seen from the Table that fortification of iron @ 40 ppm resulted in significant reduction in flavour and overall acceptability scores after 30 days of storage. Iron fortified samples @ 30 ppm remained acceptable up to 90 days of storage.

Table 5: Effect of different levels of FA on sensory attributes of kulfi during storage at - 18+2 °C

Concentration of iron (ppm)	Storage period (d)				
	0	30	60	90	120
	Flavour				
0	8.17	7.83	7.58	7.25	7.08
15	8.08	7.67	7.33	7.08	6.91
30	7.83	7.58	7.25	6.75	5.25
40	7.33	7.00	5.67	-	-
C = 0.68; S = 0.59; CxS = 0.46					
	Body and texture				
0	8.17	8.17	8.17	8.17	8.00
15	8.00	7.83	7.85	7.50	7.43
30	8.00	8.00	7.92	7.90	7.83
40	8.00	8.00	7.75	-	-
C = NS; S = NS; CxS = NS					
	Colour and appearance				
0	8.00	8.00	8.00	8.00	8.00
15	7.92	7.83	7.83	7.83	7.83
30	8.08	7.92	8.00	7.92	7.83
40	8.02	8.17	7.92	-	-
C = 0.68; S = 0.59; CxS = 0.46					
	Overall acceptability				
0	8.17	7.83	7.58	7.25	7.08
15	7.91	7.50	7.25	7.00	6.67
30	7.83	7.50	7.25	6.67	5.25
40	7.33	7.01	5.67	-	-
C = 0.69; S = 0.60; CxS = 0.47					

Each observation is mean±SD of 6 replications, C= level of iron (ppm), S= storage period (days)

The data obtained for changes in flavour score of kulfi during storage at -18±2 °C are presented in Table 5. Incorporation of iron showed significant (P<0.05) effect on flavour scores of kulfi. The results indicated that the flavour score of fresh samples of kulfi was in the order of 0>15 ppm>30 ppm> 40 ppm. The flavour score of control was higher than samples containing iron. The flavour score of C declined from beginning of the storage. Amongst the experimental samples the highest rate of decrease in flavour score was observed in samples containing 40 ppm iron and the lowest rate were observed in 15 ppm iron. The flavour score of samples containing 40 ppm iron went below acceptable level (6.0) after 30 days of the storage. It became unacceptable due to pronounced oxidized metallic flavor and bitter taste. The

effect of storage on flavour scores and the interaction effect between concentration of iron and storage period was found to be significant (P<0.05).

Incorporation of iron had no significant (P>0.05) effect on body and texture and colour and appearance scores of kulfi. The effect of storage on body and texture scores and colour and appearance and the interaction effect between level of iron and storage period was found to be non- significant (P>0.05). The overall acceptability score of fresh samples of kulfi was in the order of 0>15 ppm>30 ppm> 40 ppm. Incorporation of iron showed significant (P<0.05) effect on overall acceptability scores. The effect of storage on overall acceptability scores and the interaction effect between iron concentration and storage period was found to be significant (P<0.05). The overall acceptability score of kulfi containing 30 ppm iron went below acceptable level after 90 days of the storage.

The effect of different levels of FA on acidity and melting resistance of kulfi during storage at -18+2 °C is presented in Table 6. Incorporation of iron had no significant (P>0.05) effect on acidity and melting resistance of kulfi. The effect of storage on acidity and melting resistance and the interaction effect between level of iron and storage period was also found to be non- significant (P>0.05).

Table 6: Effect of different levels of FA on selected physico-chemical attributes of kulfi during storage at -18+2 C

Concentration of iron (ppm)	Storage period (d)				
	0	**30**	**60**	**90**	**120**
	Acidity (% lactic acid)				
0	0.293	0.300	0.297	0.297	0.297
15	0.297	0.297	0.297	0.298	0.30
30	0.297	0.297	0.297	0.293	0.297
40	0.303	0.300	0.293	-	-
C = NS; S = NS; CxS = NS					
	Melting resistance				
0	36.00	37.00	36.67	37.00	37.00
15	36.67	36.67	36.33	37.00	36.33
30	36.67	36.00	37.00	36.00	36.67
40	37.00	36.00	37.00	-	-
C = NS; S = NS; CxS = NS					

Each observation is mean±SD of 6 replications, C= level of iron (ppm), S= storage period (days)

Conclusion

It can be concluded from the study that ferric ammonium citrate is a suitable iron salt for manufacture of iron fortified kulfi when added just before freezing. Fortification of kulfi with ferric ammonium citrate in kulfi at the rate of 30 ppm iron was found to be acceptable sensorily. Levels greater than 40 ppm adversely affected the acceptability of product and shelf life of product fortified with 40 ppm iron was only 30 days. Among the levels studied, addition of 30 ppm iron was found to be most suitable and provides shelf life of kulfiof 90 days at -18±2 °C storage.

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