IJFANS
International Journal of Food And Nutritional Sciences

Volume 2, Issue-1, Jan-Mar-2013 www.ijfans.com ISSN: 2320-7876

INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

Official Journal of IIFANS

INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN 2320 –7876 *www.ijfans.com*
Vol.2, Iss.1, Jan-Mar 2013

Research Paper *Open Access*

QUALITY CHARACTERISTICS OF ICE CREAM ENRICHED WITH *SPIRULINA* POWDER

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ABSTRACT

Spirulina is a rich source of nutrients namely essential amino acids, essential fatty acids**,** carotenoids, minerals and vitamins and thus can potentially represent an important staple in the human diet. The present work focuses on enrichment of ice cream with *Spirulina* with its addition in concentrations of 0.075%, 0.15%, 0.23% and 0.3% to replace 25%, 50 %, 75 % and 100 % of stabilizer respectively for ice cream preparation. With increase in level of *Spirulina* there was improvement in nutritional profile, increase in over run and penetration value and decrease in whipping rate was observed. It also gave natural light green color to ice cream enriched with it. Ice cream prepared by replacing 50 per cent stabilizer with *Spirulina* had comparable scores for sensory parameters with that of control.

Keywords: Ice cream, *Spirulina*, Stabilizer, Enrichment.

INTRODUCTION

Nutritional and physico chemical attributes are important deciding factor when consumers purchase dairy products. Driven by increasing incomes and health consciousness value addition to dairy products has witnessed a significant increase over the past few years. Ice cream is considered a food for enjoyment, rather than a basic food. Therefore fortification of ice cream with nutrients or other bioactive substances should be supported. Additives like colours, stabilizers and emulsifiers are used in the manufacture of milk products. On several occasions the bio-safety of food is threatened due to addition of synthetic additives in food as they may inhibit the absorption of some nutrients and cause allergy. Dairy products enriched with minerals, proteins and essential fatty acids can be manufactured using cyanobacteria. It also gives natural colour to ice cream enriched with it. In the present investigation, it is of interest to explore the effect of *Spirulina* on characteristics of ice cream.

MATERIALS AND METHODS

Parry's Organic *Spirulina,* Skim milk powder of 'SAGAR' brand manufactured by Mother Dairy, stabilizer (Sodium alginate) and emulsifier (GMS) were procured from local market. Milk and cream was procured from student experimental dairy plant, Dairy Sc. College, Bangalore. Chemicals and reagents used were of AR grade.

PREPARATION OF *SPIRULINA* SOLUTION FOR INCORPORATION INTO ICE CREAM

Spirulina solution was dispersed in milk during mix preparation at 0.075%, 0.15%, 0.23% and 0.3% to replace 25%, 50 %, 75 % and 100 % of stabilizer respectively for ice cream preparation before homogenization. Desired amount of *spirulina* powder was dissolved in 15ml distilled water at 25 ^{o}C and mixed with help of magnetic stirrer for 20 minutes. This solution was kept for hydration for overnight at refrigeration temperature for hydration. Before using for product preparation this was remixed for 15 minutes with magnetic stirrer.

PREPARATION OF ICE CREAM

The ice cream was prepared as per standard procedure narrated by Sukumar De (1977). Similarly another set of ice cream was prepared by completely replacing the traditional stabilizers by *spirulina* ranging upto concentrations of 0.3%.

SENSORY ANALYSIS

A panel of four judges evaluated the control and modified products of ice cream. The products was judged with standard score card for flavour, body and texture, colour and appearance, melting quality and overall acceptability.

PHYSICO- CHEMICAL PARAMETERS

Viscosity, overrun, melting resistance was calculated per Arbuckle, 1986. Hardness was calculated using penetrometer. The freezing point was determined by using as cryoscope (Cyrostar I 'Advanced milk instruments

manufacture', USA).

STATISTICAL ANALYSIS

Average scores secured by experimental samples were compared with those of the control samples and the results were analyzed by using completely randomized design for one way ANOVA by using SPSS-10 software.

RESULT AND DISCUSSION

Composition of *spirulina* powder was determined on dry weight basis. The average percentage value of 63%, 22%, 6%, 8% and 1% were recorded for protein, carbohydrate, fat, minerals and moisture respectively.

GROSS COMPOSITION OF ICE CREAM PREPARED BY REPLACING STABILIZER WITH *SPIRULINA*

Spirulina can be used for improving nutritional quality and functional characteristics of ice cream. In view of rich chemical composition with health beneficial nutritional profile (Richmond 1996 and Moorhead *et al.,* 2006) and functional properties of *Spirulina*, it is used in this investigation to replace stabilizer partially or fully used in preparation of ice cream with natural resource. At the same time owing to its rich nutritional profile the replacement of stabilizer with *spirulina* in ice cream resulted in higher proteins, minerals, essential fatty acids and trace elements of natural origin.

The effect of replacement of stabilizer with *spirulina* on gross composition of ice cream is indicated in Table I.Observed increase in protein and fat content and decrease in carbohydrate content was found to be non significant, the rate of increase in minerals from 0.48 in control to 0.51% in ice cream prepared by replacing 100% stabilizer with spirulina and iron content from 0.03 mg/100g in control to 0.20 mg/100g in ice cream prepared by replacing 100% stabilizer with spirulina was found to be statistically significant.

Milk being poor source of iron, the substitution of stabilizer with *spirulina* had beneficial impact on enhancing the iron content of ice cream. Henrickson (2009) reported the very high iron content of *spirulina* should be stressed because iron deficiencies (anaemia) are widespread, particularly in pregnant women and children, and good sources in food are rare. As a comparison, iron supplements given in form of ferrous sulfate can pose a toxicity problem and often cause diarrhea. Cereals are rich in phytic acids and phosphatic polymers, which sharply limits the bioavailability of the iron they contain. In the case of *spirulina*, iron bioavailability has been demonstrated both in rats and in humans without any side effects. Thus replacement of stabilizer with *spirulina* has nutritional beneficial effect in fortifying iron content of the enriched ice cream. The compositional change of ice cream may be attributed to the inherent composition of *Spirulina*.

Table I: Effect of replacement of stabilizer with spirulina on gross composition of ice cream

Extent of stabilizer replaced (%)	Chemical Composition (%)					
	Total Solids	Protein	Carbohydrate	Fat	Ash	Iron (mg/100ml)
0	35.83	4.26	20.95	10.11	0.48	0.03
25	35.87	4.31	20.89	10.11	0.49	0.07
50	35.91	4.36	20.83	10.12	0.49	0.11
75	35.96	4.41	20.77	10.12	0.50	0.16
100	36.01	4.45	20.72	10.13	0.51	0.20

ANOVA SUMMARY

SEM	0.52	0.037	0.217	0.0001	0.0001	0.0001
F Value	0.05	0.43	0.68	2.1	3.9	138.9
CD	NS	NS	NS	NS	0.02	0.02

EFFECT OF REPLACEMENT OF STABILIZER WITH *SPIRULINA* ON PHYSICAL PROPERTIES OF ICE CREAM MIX PH AND ACIDITY

The increases in replacement of stabilizer with spirulina at levels ranging from 0 to 100 per cent resulted in significant increase in acidity from 0.20 to 0.25 percent lactic acid and correspondingly decrease in pH from 6.33 to 6.11 (Table II) indicating that the added *spirulina* alter pH and acidity values and thus it influence these physical properties. The natural acidity in ice cream mix is due to milk proteins, mineral salts and dissolved gases (Arbuckle, 1986). As a result of increased level of SNF in milk, the titrable acidity of milk increased due to buffering action of the additional proteins, phosphates, citrates, lactates and other miscellaneous milk constituents (Walstra and Jenness, 1984). The increase in acidity in ice cream prepared by replacing stabilizer with spirulina may be attributed to the chemical composition of *spirulina*. Addition of spirulina in ice cream to replace stabilizer resulted in higher protein and mineral content which might be the possible reason for increase in acidity of ice cream mix.

Table II: Effect of replacement of stabilizer with spirulina on physical properties of ice cream mix

Extent of stabilizer replaced (%)	pH	Acidity (%LA)	Viscosity (cp)
0	6.33	0.20	31.5
25	6.20	0.21	31.2
50	6.15	0.22	30.6
75	6.12	0.23	28.8
100	6.11	0.25	26.6

ANOVA SUMMARY

SEM	0.00034	0.0001	0.25
F Value	69.39	15	66.876
CD	0.04	0.02	0.90

VISCOSITY

Viscosity of ice cream is one the vital physical property that helps in maintaining all the components in homogeneous state. The present study (Table II) showed decrease in viscosity with increase in level of replacement of stabilizer with *spirulina*. All the stabilizers have an ability in varying degrees to increase the viscosity of mix, and these stabilizers have high water holding capacity and function through their ability either to form gel structure in water or to combine with water as water of hydration, to improve the body, restrict ice crystal growth during storage and control the rate of melt down (Cottrell *et al*., 1980).

Spirulina is known to possess water binding capacity of 1.45 g water/ g of protein (Robinson *et al*., 2000). The viscosity of ice cream mix till 50 percent replacement level of stabilizer with *spirulina* were almost comparable to that of control which decreased to lower values thereafter. Similar studies were carried out by Shilpa (2009) to replace stabilizer with casein fraction. Water binding capacity (WBC) of casein is about 2.5 g water/ g protein (Fox and McSweeny, 1998). Shilpa (2009) concluded that the casein fractions can be satisfactorily employed to replace stabilizer used in ice cream preparation. Hence, as spirulina posses lower water holding capacity; this could be the possible reason for reduced viscosity. It can be concluded that *spirulina* can be used to replace stabilizer only partially and not completely.

EFFECT OF REPLACEMENT OF STABILIZER WITH *SPIRULINA* ON PROCESSING PARAMETERS OF ICE CREAM OVERRUN

Overrun is mainly due to incorporation of air into the mix during freezing. Rapidity with which the ice cream mix incorporates air is attributed to optimum level of total solids inclusive of additives viz., stabilizers and emulsifiers (Chang and Hartel, 2002). The results obtained in present investigation showed that ice cream prepared by replacing stabilizer with *spirulina* at 100% level recorded an increase

Table III: Effect of replacement of stabilizer with spirulina on processing parameters

Extent of stabilizer replaced (%)	Over run (%)	Whipping (min)	Freezing point (^{o}C)
0	90.6	6.5	-3.4
25	91.0	6.0	-3.6
50	91.7	5.5	-3.7
75	93.2	5.0	-3.8
100	95.0	4.0	-3.8
ANOVA SUMMARY			
SEM	1	0.25	0.01
F Value	9.78	11.1	8.4
CD	1.82	0.90	NS

in overrun to 95% from overrun of 90.6% recorded for control (Table III). The improvement in the overrun upon addition of *spirulina* could be attributed to the surface active properties of the protein and fat content present in *spirulina. Spirulina* is known to possess emulsifying capacity of 1.13 ml fat/ g protein, foam capacity of 207% and foam stability of 27% (Robinson *et al.*, 2000).

The percent of overrun obtained for experimental samples were significantly higher than that of control. The improvement in over run is of importance in favoring the smoother body and texture, dryness and desirable melting properties of ice cream.

WHIPPING RATE

Whipping is the process of incorporation of air into the ice cream mix. The rate of whipping is measured in minutes. Rapidity with which the ice cream incorporates air is measured in terms of whipping rate. The whipping rate of 4.0 minutes was recorded in ice cream prepared by replacing 100% stabilizer with spirulina as against control which recorded whipping rate of 6.5 minutes. There is an improvement in whipping rate as evidenced by decreased time taken for whipping in case of ice cream added with *spirulina* (Table III).

Thus S*pirulina* contribute to better whipping rate besides acting as a stabilizer. This is due to greater foaming and emulsifying capacity of fat and protein contents of *spirulina* which helps in formation and stabilization of dispersed gas i.e., incorporated air. *Spirulina* is known to possess emulsifying capacity of 1.13ml fat/ g protein, foam capacity of 207% and foam stability of 27% (Robinson *et al.*, 2000).

FREEZING POINT

Freezing point of ice cream is mainly dependent on the concentration of soluble components present in it. The increase in freezing point from -3.4 to -3.8 ^{o}C was observed with increase in replacement of stabilizer with spirulina in ice cream. This observed increase in freezing point may be attributed to the high mineral matter found in *spirulina* (Henrickson, 2009). However, the observed difference in freezing point between the different treatments were found to be non significant.

EFFECT OF REPLACEMENT OF STABILIZER WITH *SPIRULINA* ON RHEOLOGICAL CHARACTERISTICS OF ICE CREAM

HARDNESS

The hardness was measured by using a penetrometer. The results indicate that the increase in level of replacement of stabilizer with *spirulina* from 0 to 100% resulted in increased penetration value from 110.0 to 121.0 (mm/5 sec) (Table IV) indicating decreased hardness of ice cream. This decreased hardness with increased level of replacement of stabilizer with *spirulina* was found to be significant. It can be concluded that incorporation of *spirulina* resulted in imparting desired soft body to the ice cream. Further, the results obtained in present investigation showed that ice cream prepared by incorporating *spirulina* recorded higher overrun and subsequently recorded increase in penetration value (Table IV). These results were in accordance with Sofijan and Hartel (2004) who reported that as overrun

increases ice cream become softer as indicated by higher penetration value of ice cream.

MELT DOWN PROPERTY

Meltdown property is attributed to water holding capacity which refers to the properties involving interaction between the protein, product and water as a result of which some of the water remains with the product (Pour-EI, 1981). It was observed from the values (Table IV) that the ice cream prepared by replacing stabilizer with *spirulina* recorded greater melting resistance. The melting resistance increased from 13.0 minute in control ice cream to 17.8 minutes in ice cream in which 100 percent of stabilizer is replaced with *spirulina*. The increase in melting resistance in ice cream prepared by replacing stabilizer with spirulina was found to be significant in comparison to control. Sofijan and Hartel (2004) reported that stabilizers have water holding and fat absorption capacity which influence rheological properties of ice cream mix. This greater melting resistance may be attributed to the water absorption capacity of 1.45 g/g protein and fat absorption capacity of 3.73 g/g protein of *spirulina* (Robinson *et al.*, 2000). Further, the high protein content present in spirulina may be helpful in stabilizing the air cells and thereby imparting greater melting resistance (Sofijan and Hartel, 2004).

EFFECT OF REPLACING STABILIZER WITH *SPIRULINA* ON SENSORY CHARACTERISTICS OF ICE CREAM

The scores obtained for ice cream prepared by replacing stabilizer with *spirulina* at 25 percent level are comparable to that of control for flavor, body and texture and melting quality. The scores (Table V) obtained for ice cream prepared by replacing stabilizer with *spirulina* at 50 percent level was higher than that of control. This may be attributed to the functionality of *spirulina*. The product recorded higher scores for body and texture, colour and appearance and melting quality when compared to control ice cream. The product obtained had a light green (pista) colour which was well accepted by panel of judges. This was adjudged to be superior product when compared to other treated products. The decrease in score with increase in level of replacement at 75 and 100 percent level is mainly due to bland oily flavor, fluffy body due to increased overrun and intense green colour. These might be the causes for decreased overall acceptability of the product.

Table IV: Effect of replacement of stabilizer with spirulina on rheological properties

Extent of stabilizer replaced (%)	Hardness (mm/5sec)	Meltdown property (min)
0	110.0	13.0
25	115.2	13.6
50	116.5	14.9
75	118.0	16.2
100	121.0	17.8

ANOVA SUMMARY

SEM	9	1
F Value	5.48	11.4
CD	5.46	1.82

Table V: Sensory characteristics of ice cream prepared by replacing stabilizer with spirulina

Extent of stabilizer replaced (%)	Colour & appearance (10)	Flavor (45)	Body & texture (30)	Meltdown characteristics (15)	Overall acceptability (100)
0	8.70	42.00	25.70	13.90	90.20
25	9.20	42.50	25.70	12.80	90.20
50	9.20	42.30	27.30	13.60	92.40
75	8.40	41.50	24.90	12.00	86.80
100	7.00	39.80	24.80	11.80	83.30

ANOVA SUMMARY

SEM	0.01	1	0.25	0.04	5.38
F Value	241.79	3.7	12.5	71.14	7.76
CD	0.18	1.82	0.90	0.36	4.22

- All values are average of three trials, NS: Non ignificant at 5% level

CONCLUSION

The present work focuses on enrichment of ice cream with *Spirulina* due to its rich chemical composition. Besides enrichment, addition of *Spirulina* also resulted in replacement of stabilizers in ice cream preparation as its composition is 60% proteins only. *Spirulina* powder can be used in concentration of 0.15 per cent to replace 50 percent stabilizer in ice cream preparation without affecting the sensory attributes of the product. *Spirulina* powder addition also gave natural light green (pista) color to ice cream and yoghurt enriched with it. Thus from present study it can be concluded that *Spirulina* powder offers great potential use in diary industry to enrich dairy products and to substitute synthetic additives viz., colours, stabilizers and emulsifiers etc., employed in various dairy products.

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