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Physico-chemical attributes of noni (*Morinda citrifolia*) incorporated functional ice cream

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Abstract
Increased consumer interests in improving overall health have triggered the demand for functional dairy foods that give health benefits beyond their traditional nutritional value. In this regard, a study was carried out to prepare health giving noni (*Morinda citrifolia*) incorporated ice cream of acceptable sensorial attributes. Different treatments of ice cream prepared by supplementing noni at 5, 7.5 and 10 % levels were designated as NSIC1, NSIC2 and NSIC3 respectively and the ice cream prepared without supplementing noni kept as control was designated as CIC. The prepared ice creams have been subjected to various physico-chemical properties and compared with the control. The pH and titrable acidity showed that there was no significant difference between different treatments of ice cream. But the specific gravity, viscosity were increased with the increased level of addition of noni, whereas meltdown, hardness and over run were decreased with the increased level of addition of noni to the ice cream significantly. It is concluded that the noni supplemented ice cream prepared by supplementing 7.5% noni seems to be good because of its acceptability in comparison with other types of the ice cream.

Keywords: Ice cream, Noni (*Morinda citrifolia*), Physico-chemical properties

Introduction
Ice cream is a delicious, nutritious, healthful, relatively inexpensive frozen dairy product and is composed of milk ingredients, sugar, stabilizer and emulsifiers in addition to colouring and flavouring materials. It is very popular among all sections of the people because of the food and health aspects ranging from 'taste delight to nutrient delivery'. A typical compositional range for the components used in ice cream mix is milk fat 10-16%, milk solids not fat 9-12%, sucrose 9-12%, stabilizers/emulsifiers 0-0.5%, total solids 36-45% and water 55-64% (Goff, 1997) [2]. Though ice cream has nutritional significance but possesses no therapeutic properties.

As a matter of fact, value addition to the ice cream has been constantly tried by incorporation of different types of ingredients that gives health benefits to the ice cream. Most of the consumers of today prefer food products with therapeutic value for their health aspects over their palatability. Increased consumer interest in improving overall health and reducing risk for specific diseases has fuelled the demand for functional foods and beverages that provide health benefits beyond their traditional nutritional value (IFIC, 2007 & 2008) [3-4].

Hence, an attempt has been made to impart therapeutic attributes to the ice cream by incorporation of *Morinda citrifolia*, commonly known as Great morinda, Indian mulberry, beach mulberry which has been used in tropical regions as both food and folk medicine. Noni contains numerous phytochemicals, antioxidants, vitamins and micro and macronutrients which help us in various ways from cell to self. This traditional fruit has been used as a health panacea to all the disease. Noni juice is the fastest growing health product in the world today and contains a unique blend of phytonutrients, selenium and proxeronine. Proxeronine is the basic building block of body immune system and noni fruit is vested with highest content of proxeronine. Noni is used as food supplement to treat health conditions such as arthritis, tumour and cancer besides various allergies and asthma (Shah and Gupta, 2006) [12]. Apart from this about 160 phytochemical compounds have been already identified in the noni plant, and the major micronutrients are phenolic compounds, organic acids and alkaloids. Polynesians healers have used noni as folk medicine for over 2000 years because of its potential protective health benefits (Zin *et al*., 2006) [18]. Noni is non-conventional under-

utilized product fruit is much valued in today's emerging overly healthy conscious societies for its therapeutic health enhancing attributes like antibacterial, anti- inflammatory, analgesic and anti-congestive properties. Noni and its products are used as a health panacea against high blood pressure, respiratory problems and immune deficiencies (Shah and Gupta, 2006) [12].

Materials and Methods

The studies were carried out in the Model Dairy plant, Department of Livestock Products technology(Dairy Science), Madras Veterinary College, Vepery, Chennai – 600 007. All the ingredients including Noni extract were procured from the local market.

Preparation of Noni supplemented Ice cream

Noni supplemented ice cream mixes were prepared by pasteurizing (68^0 C for 30 min) a mix containing skim milk, cream, skim milk powder, sugar, stabilizer and emulsifiers. Ice cream was prepared by supplementing noni fruit at 5, 7.5 and 10 per cent levels. The mixes were then homogenized at 2000/500 psi and ice cream mix were kept for ageing at 4^0 C for 4 hours and for freezing at - 4^0 C. After packing the ice cream were kept for hardening and storage at -23^0 C.

Flow chart for the preparation of treatment ice cream

Selection of Ingredients
(Skim milk, cream, skim milk powder, sugar, noni fruit, stabilizers emulsifiers and flavour)
↓
Figuring the mix
↓
Making the mix
↓
Pasteurizing the mix (68.5^0 C for 30 min)
↓
Homogenizing the mix (150 kg / cm ^{2} & 30 kg / cm ^{2} at 65^0 C)
↓
Cooling and ageing the mix (4 ± 1^0 C for 4 hrs)
↓
Addition of noni at different levels (5%, 7.5%, 10%)
↓
Freezing the mix (– 4 to - 5^0 C)
↓
Packaging of Ice Cream
↓
Hardening and storage of Ice cream (– 23 to - 29°C)

The noni was supplemented at different levels as follows.
NSIC 1 -Ice cream mix with supplementation of 5% noni
NSIC 2 -Ice cream mix with supplementation of 7.5% noni
NSIC 3 -Ice cream mix with supplementation of 10% noni.
Ice cream prepared without supplementing noni was kept as a control and designated as CIC.

Estimation of physico-chemical properties of ice cream

Physico chemical analyses of Noni supplemented ice cream

Acidity was estimated as per the procedure described in IS:SP:18 (part XI)-1981 and pH was estimated by digital pH meter. The specific gravity of frozen yoghurt was estimated by gravimetric method using specific gravity bottle as per the method of Sommer (1951) [13]. The hardness ice cream was analyzed by using the texture analyzer (model: TA XT plus, stable Microsystems), keeping all the determinations at 15^{0}C (Steff, 1996) [14]. The relative viscosity was determined by pipette method. The meltdown time was estimated following the procedure outlined by Rajor (1982) [10]. The over run was estimated by the procedure outlined by Sukumar De (1980) [15].

Results

Physico chemical properties of noni supplemented ice cream

pH

The mean pH ± SE values of different ice cream were recorded and their analysis of variance is presented in Table 1. The mean pH ± SE values of different ice cream viz. CIC, NSIC1, NSIC2 and NSIC3 were 6.333±0.056, 6.383±0.031, 6.417±0.040.and 6.450±0.056 respectively. Statistical analysis showed that there was no significant ($p > 0.05$) difference with regard to pH of different treatments of ice cream.

Titratable acidity

The mean titratable acidity ± SE values of different ice cream and their analysis of variance are presented in Table 1. The mean titratable acidity ± SE values of ice cream viz. CIC, NSIC1, NSIC2 and NSIC3 were found to be 0.245±0.003, 0.238±0.001, 0.235±0.005 and 0.233b±0.003 respectively. Statistical analysis indicated that there was no significant ($P > 0.05$) difference with regard to titratable acidity of different treatments of ice cream.

Specific gravity

The mean specific gravity ± SE values of different ice cream and their analysis of variance are presented in Table 1. The mean specific gravity ± SE values of ice cream viz. CIC, NSIC1, NSIC2, and NSIC3 were found to be 1.082±0.0007, 1.097±0.0006, 1.114±0.0005 and1.128±0.0007 respectively. Statistical analysis showed a highly significant ($P \leq 0.01$) difference in specific gravity values between different treatments of ice cream. The mean value of the specific gravity of the different types of ice cream was higher than the control ice cream and the gradual increase of the specific gravity is positively correlated with the increase in level odf addition of of noni. The highest specific gravity was recorded in the ice cream supplemented with noni at 10% level.

Viscosity

The mean viscosity ± SE values of different ice cream and their statistical analysis of variance are presented in Table 1. The mean viscosity ± SE values of ice cream viz. CIC, NSIC1, NSIC2, and NSIC3 were found to be 41.710±0.164, 38.790±0.402, 36.787±0.290 and 35.083±0.228 respectively. Statistical analysis showed a highly significant ($P \leq 0.01$) difference in specific gravity values between different treatments of ice cream. The mean value of the viscosity of different types of ice cream is higher in control ice cream and the viscosity was decreased gradually as the level of addition of noni is increased. The highest viscosity was observed in the ice cream prepared without supplementation of noni.

Meltdown

The mean meltdown ± SE values of different ice cream and their analysis of variance are presented in Table 1. The mean meltdown ± SE values of ice cream viz. CIC, NSIC1, NSIC2 and NSIC3 were 14.167±0.477, 12.667±0.667, 11.833±0.307 and 10.333±0.494 respectively. Statistical analysis showed

that there was a significant (P ≤0.05) difference with regard to meltdown time of different ice cream. The mean value of the meltdown of different types of ice cream decreased as the level of addition of noni is increased. Ice cream supplemented with noni at a level of 10% melt faster when compared to other treatment categories.

Hardness

The mean hardness ± SE values of different ice cream and their analysis of variance are presented in Table 1. The mean hardness ± SE values of ice cream viz. CIC, NSIC1, NSIC2 and NSIC3 were 1364.540±8.213, 1067.833±9.673, 984.667±4.200 and 877.500±3.897respectively. Statistical analysis showed that there was highly significant (P ≤0.01) difference with regard to hardness of different ice cream. The mean value of the different types of ice cream was in decreasing order and is negatively correlated with the level of incorporation of noni.

Overrun

The mean overrun ± SE values of different ice cream and their analysis of variance are presented in Table 1. The mean overrun ± SE values of the ice cream viz. CIC, NSIC1, NSIC2 and NSIC3 were found to be 39.583±1.004, 40.833±1.054, 42.917±1.193 and 44.167±0.833 respectively. Statistical analysis showed that there is highly significant (P ≤ 0.05) difference with regard to overrun of different ice cream. The mean value of the different types of the ice cream than the control ice cream and the overrun was increased according to the increased level of addition of noni. The highest overrun was recorded in the ice cream incorporated with noni at 10% level.

Table 1: Physico chemical properties of noni supplemented ice cream

Types ice cream	Physico chemical properties (Mean ± SE)@						
	pH	Titratable acidity	Specific gravity	Viscosity (centipoises)	Melt down (minutes)	Hardness (g)	Over run (per cent)
CIC	6.333±0.056	0.198±0.009	1.082^{d}±0.0007	41.710^{a}±0.164	14.167^{a}±0.477	1364.540^{a}±8.213	39.583^{a}±1.004
NSIC 1	6.383±0.031	0.207±0.009	1.097^{c}±0.0006	38.790^{b}±0.402	12.667^{a}±0.667	1067.833^{b}±9.673	40.833^{a}±1.054
NSIC 2	6.417±0.040.	0.218±0.007	1.114^{b}±0.0005	36.787^{c}±0.290	11.833^{a}±0.307	984.667^{c}±4.200	42.917^{a}±1.193
NNIC 3	6.450±0.056	0.222±0.008	1.126^{a}±0.0007	35.083^{d}±0.228	10.333^{b}±0.494	877.500^{d}±3.897	44.167^{a}±0.833
F value	1.12^{NS}	1.65^{NS}	621.91**	99.69**	3.99*	901.23**	3.63*

@Average of six trials (different superscript in a column differ significantly)
^{NS} not Significant
* Significant
** Highly significant

Discussion

pH and Titrable Acidity

There was no significant (P > 0.05) difference with regard to pH and titratable acidity between different treatment groups of ice cream. But there was a decrease in the pH and increase in the acidity of the ice cream according to increasing levels of the addition of noni. This is due to the non milk solids (NMS) present in the ice cream. The normal titratable acidity of mixes varies with the percentage of NMS contained and may be calculated by multiplying the percentage of NMS by the factor 0.017. If the mix containing 11% NMS would have the normal titratable acidity of 0.187%. The pH of the noni juice (pH 3.4-3.6) and also the higher protein and solids content in the noni fruit might be responsible for the increasing the acidity of the ice cream. This is in line with the observations of Pinto *et al*. (2005) [8] that there was increase in the acidity of ice cream due to addition of ginger shreds and attributed higher solid content.

Specific gravity

There was highly significant (P ≤ 0.01) difference in specific gravity values of different treatment ice cream. The density of ice cream depends on two factors viz., the density of the ingredient mixture and the expansion or "overrun" that occurs due to freezing and introduction of air. As the density of cream is very close to that of water - on the order of 1.008 Kg/L for heavy cream, the other ingredients, such as sugar, flavouring and other additives may increase or decrease the density. The control ice cream recorded the lowest specific gravity and the NSIC3 shown the highest specific gravity. As noni juice used in this study had a specific gravity of 1.015, it positively correlated with the increase in specific gravity of different treatment category of noni supplemented ice cream and in the increasing order of incorporation of Noni. These findings were in close accordance with the findings of Samahy *et al*, (2009) [11], who recorded that specific gravity was in the increasing order and is positively correlated with the increased level of addition of cactus pear pulp in the ice cream.

Viscosity

Viscosity is considered an important characteristic of ice cream, since it frequently accompanies the desirable body and texture (Innocente *et al*., 2002) [5]. Statistical analysis exhibited a highly significant (P ≤ 0.01) difference in viscosity among different treatments of ice cream. The noni supplemented ice creams recorded higher viscosity than the control ice cream. Among the treatment groups, NSIC3 has shown the highest viscosity. As Ice cream mix possess both apparent viscosity, i.e., the measured viscosity progressively decreases as the shear rate increases and true viscosity, the resistant to flow that remains after the apparent viscosity disappears, the viscosity of ice cream mixes were greatly affected by composition that is fat, salts, protein and total solids. The processing steps like pasteurization, homogenization and ageing and also the handling of the mixes had an influence on the viscosity. This is similar to the reports of Temiz and Yeşilsu (2010) [16] that addition of pekmez to the ice cream mixtures decreased the viscosity of the ice cream.

Meltdown

There was a significant difference (P ≤0.05) with regard to meltdown characteristic of different treatments of ice cream. The NSIC3 melted faster than others and the melt down time is negatively correlated with the addition of noni. The viscosity of the ice cream mix had an influence on the meltdown time and it is observed in this study that there was a decrease in melting resistance when there was a decrease in viscosity. It can also be opined that higher total solids in Noni

may have an impact and higher melt down rate was recorded. This is similar to the findings of the Li *et al*. (1997) [6], who reported that ice creams with high total milk solids (39%) melted faster than those with lower total solids and attributed to the effect of dissolved solids on the freezing point depression. These reports were also closely related with the reports of the Temiz and Yeşilsu (2010) [16] who concluded that presence of pekmez in the ice cream caused a marked increase in the melting rate compared to those without pekmez and the melting rate was increased in a positive correlation to the increase in the addition of pekmez in the ice cream.

Hardness

There was a significant difference (P ≤0.05) with regard to hardness characteristic of different treatments of ice cream. The control ice cream showed the highest hardness when compared the other types of ice cream. The hardness value negatively correlated with the addition of noni to the ice cream and the ice cream supplemented with 10% noni recorded the least hardness. Muse and Hartel (2004) [7] opined that hardness is affected by the overrun, ice crystal size, ice phase, ice volume and extent of fat destabilization. These findings were closely related with the findings of Prindiville *et al.* (1999) [9] and Abd El- Rahman *et al.* (1997) [1] who concluded that lower overruns (and subsequently larger ice crystals) in ice cream lead to decreased hardness. Contrary to this, Wilbey *et al.* (1997) [17] observed that the presence of air (high % overrun) decreased the hardness of ice cream. Thus, contradictory results relating air content and hardness in ice cream have been observed and may be attributed to differences in secondary effects (ice crystals, etc.).

Overrun

There was a highly significant (P ≤ 0.01) difference in overrun percentage between different treatments of ice cream. The ice cream supplemented with 10% noni had the highest over run among the ice cream and it was observed that increase in the overrun was recorded with the increase in levels of addition of noni. As the viscosity greatly influences the overrun of the ice cream and increase in the viscosity leads to the deleterious effect in the over run of the ice cream. There was a marked decrease in the viscosity of noni supplemented ice cream as the percentage of addition of noni increases and the lowest viscosity was observed in the ice cream supplemented with noni at 10% level (NSIC 3). As the overrun increases, the ice cream become softer so that the hardness values were also reduced.

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