



Physico-Chemical and Sensory Qualities of Ice Cream Incorporated with Encapsulated Flavour

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ABSTRACT

Flavour is the most important positive attribute in ice cream. However its stability in ice cream during processing and storage get decreased. In order to limit its degradation in ice cream during processing and storage it is beneficial to encapsulate flavor compounds. The aim of this study is to evaluate flavor encapsulated (FE 1 and FE 2) compounds, physico-chemical of different flavor encapsulated ice cream (FEIC 0, FEIC 1, FEIC 2) and sensory qualities of different flavor encapsulated ice cream on different days (0 day, 7th day and 15th day). The ice cream were prepared with 1.35 % of FE 1 and FE 2 in ice cream and were analyzed for physico-chemical and sensory qualities and compared with regular ice cream (control – FEIC 0). The result of the present study shows that shape of the aggregated encapsulated flavour were irregular, but it is spherical in shape when it is dispersed. The size of the aggregated FE 1 and FE 2 did not differ significantly, but size of the dispersed and solubility of different encapsulated flavor differed significantly (< 0.01). Among physico-chemical properties, ice cream incorporated with encapsulated flavour significantly increased (< 0.05) viscosity and melting resistance of the ice cream, but it has not having any influence on pH, titratable acidity (%), fat (%), total solid (%) and specific gravity when compared with control ice cream (FEIC 0). In sensory qualities, colour and appearance of different flavour encapsulated ice cream did not differ significantly on different storage period. The intensity of flavour was significantly higher (< 0.01) in FEIC 0 on 0th day and non-significant among treatments on 7th day. But on 15th day the intensity of flavour was significantly higher in FEIC 1 and FEIC 2 when compared with FEIC 0 were analyzed using sensory panelist. Thus the study revealed that incorporation of FE compound in ice cream improves flavor stability in ice cream without affecting much of its physico-chemical properties.

Key words: Encapsulation, Flavour compound, Flavour stability, Physico – chemical, sensory parameter.

INTRODUCTION

Ice cream, a frozen dairy product includes milk, sweetener, stabilizer, emulsifier and flavoring agent and is produced by mixing its ingredients and finally freezing it Frost *et al.* (2005) and Karaman and Kayacier, (2012). Ice cream is commonly enjoyed by all age groups due to its natural cooling effect and high nutritional value. Flavour plays an important role on the quality and acceptability in ice cream, but being difficult to control. Many factors linked to aroma affect the overall quality, generally in foods, like physico-chemical properties, concentration and interaction of flavour molecule with food components etc (Landy *et al.* 1995).

Since flavour is one of the most important characteristics of any food, the ultimate goal of encapsulation is to control aroma release and to improve the stability during processing, storage and consumption of the final product (Nedovic *et al.* 2011). Encapsulation is a process to cover an active compound with a protective wall material and it can be employed to treat flavour so as to impart some degree of protection against evaporation, chemical reactions (such as flavour – flavour interaction, light induced reaction, oxidation or migration in a food (Madene *et al.* 2006). Considering the above facts, an attempt has been made to encapsulate flavour compound with suitable wall materials for its sustained release and stability and to prepare ice cream using the encapsulated flavour compound.

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MATERIALS AND METHODS

The ingredients like fresh milk, cream and skim milk powder for preparation of different flavor encapsulated ice cream were obtained from local market of Chennai. All other chemicals used for encapsulation of flavor compound and for ice cream preparation were food graded were purchased from Sigma Aldrich. The work was carried out during in the Department of Livestock Products Technology (Dairy Science), Madras Veterinary College, Chennai -07 during 2012 – 13 to 2013 -2014.

Preparation of flavor encapsulated compound

Emulsion formation

For FE 1 the emulsion was prepared by dispersing 15% w/v maize starch, 0.1% w/v gum powder, carrageenan 0.1% w/v to the boiled rice water extract and made up to 1 liter. For FE 2 the emulsion was prepared by dispersing 15% maltodextrin and 15% whey protein powder to the normal distilled water and made up to 1 liter. This mixture was stirred until the wall materials gets completely dissolved. The total solid concentration of this composition of wall materials was fixed at 20%. The liquid ice cream flavour compound was then added to the wall material solution at the concentration of 15% with respect to the total solids. Emulsions were formed using an ultra-Turrax homogenizer operating at 8000 rpm for 10 min as per the method Fernande *et al.* (2014).

Spray drying

The above formed emulsions were spray dried using laboratory scale spray drier. The pressure of compressed air for the flow of the spray was 1.4 psi. The emulsion was fed by peristaltic pump. The inlet and the outlet air temperature were maintained at 160 to 170°C and 70 to 75°C. These spray dried flavour encapsulated compounds were packed in UV sterilized LDPE bags and stored at room temperature.

Analysis of the flavour encapsulated compound

Shape and size of the flavour encapsulated compound

Scanning electron microscopy was used to study the size of the encapsulated flavour. The samples were fixed directly on door – metallic specimen (stubs) of 12 mm diameter and then subjected to metallization (sputtering) with a thin layer of gold/palladium in a Sputter coater at a coverage rate of 0.51 A/s for 180 s. After metallization, the samples were observed with magnification of 200, 1000 and 2000 X.

Solubility

The beadlet solubility in water was determined according to Santos 2003. The mixture of the beadlet in the water solution (0.4% w/v) was gently stirred until solid solubilization. The beadlet was considered soluble when the time of solubilization was not greater than 5 min. The time necessary for complete beadlet solubilization was recorded. This determination was conducted in triplicate.

Preparation of ice cream

Six different lots of ice cream were prepared as per the Bureau of Indian Standard Specification IS: 2802 (1964).

Before freezing the mix at – 4 to – 5°C the different flavour encapsulated compound were added to the ice cream mix. Different treatment of flavour encapsulated ice cream were denoted as FEIC 0, FEIC 1 and FEIC 2 incorporated with regular ice cream flavour FE 0, flavour encapsulated compound FE 1 and FE 2 respectively were indicated in Table 1.

Physico-chemical analysis of ice cream

The pH of the ice cream mix was estimated after ageing using digital pH meter, while the titratable acidity was calculated as percentage of lactic acid was determined by titration with 0.1N of sodium hydroxide as per the BIS procedure IS:1479 - Part I (1960). Fat content of the ice cream was estimated by using modified Gerber method AOAC (2004). Total solids were estimated as per BIS procedure IS: 2802 (1964). The specific gravity of ice cream mix was measured by weighing a known volume of mix using a specific gravity bottle on a gravimetric balance (Sommer, 1951). The viscosity was estimated as per the BIS procedure IS: 1479 - Part 1 (1960). The melting resistance was evaluated using 50 g ice cream sample block which placed on metric test sieve that was supported by a pre weighed beaker. The mass of melted ice cream collected in the beaker was recorded at 5 min time intervals for 60 min duration. The graph for mass of melted ice cream (gram) was plotted against the time (min) Alamprese *et al.* (2002).

Sensory analysis

Sensory analysis was carried out by untrained panel of judges comprising five members employing 9- point hedonic scale developed by Stones and Side (1992). All the samples were appropriately coded before subjected for sensory evaluation.

RESULTS AND DISCUSSION

Properties of flavor encapsulated beadlets

Shape and size of the aggregated and dispersed encapsulated flavour beadlet

The shape and the size of the aggregated and the dispersed flavor encapsulated beadlets were indicated in Fig 1-4 and Table 2. The shape of the aggregated beadlets were irregular and the dispersed beadlets were spherical. There was no significant difference ($P > 0.05$) was noticed between the size of the aggregated flavor encapsulated beadlets and highly significant difference ($P < 0.01$) was found between the size of the dispersed flavour encapsulated beadlets. FE 1 dispersed beadlets showed higher size value when

Table 1: Experimental design.

Types of ice cream	Percentage of substitution encapsulated flavour (%)	Milk (ml)	Cream (gm)	SMP (gm)	Sugar (gm)	Stabilizer (gm)	Liquid flavour (ml)
FEIC 0	-	750	110	50	150	5	3
FEIC 1	13.4	750	110	50	150	5	-
FEIC 2	13.4	750	110	50	150	5	-

FEIC 0 – Regular ice cream (Control), FEIC 1 - Flavour encapsulated ice cream 1, FEIC 2- Flavour encapsulated ice cream 2.

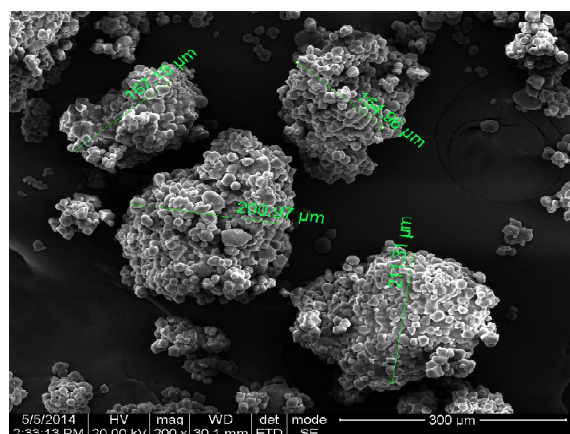
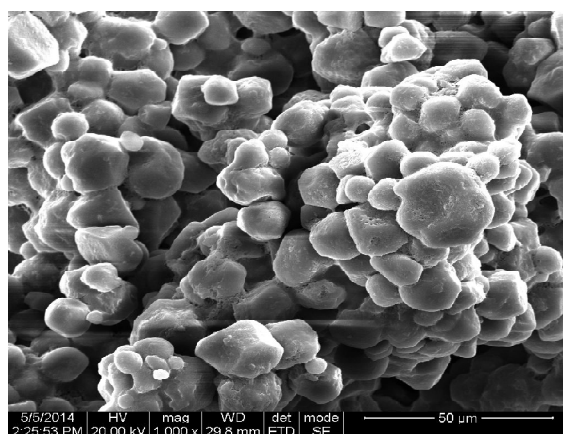
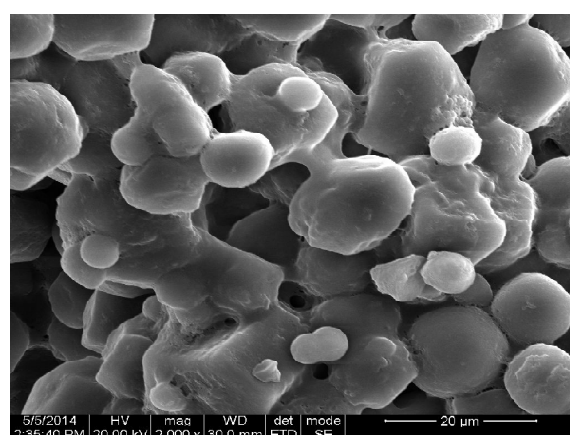
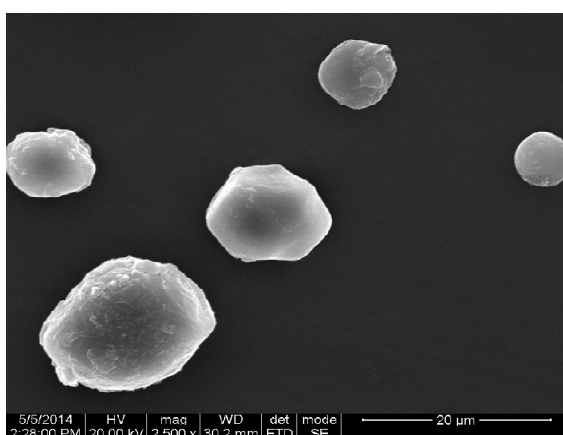
Table 2: Size and solubility of different encapsulated flavour beadlets.

Parameter	Treatments		t value
	FE 1	FE 2	
Size in aggregated form (mm)	1.73 ± 0.27	1.81 ± 0.28	15.89
Size (after dispersion in water µm)	53.50 ^a ± 1.12	25.17 ^b ± 0.82	0.64**
Solubility (min)	44.33 ^a ± 0.54	25.43 ^b ± 0.65	0.33**

n = 6

** Different superscripts in the same row differ significantly (P < 0.01).

FE 1 - Flavour Encapsulation 1, FE 2 - Flavour Encapsulation 2.

**(Under 200x magnification)****Fig 1:** Flavour Encapsulated Beadlets 1**Fig 2:** (Under 1000x magnification)**Fig 3:** (Under 2000x magnification).**Fig 4:** (Under 2000x magnification).**Fig:** Scanning electron microscopic view of flavour encapsulated beadlets under different magnifications.

compared to FE 2. This may be due to the type of wall materials, with the largest size resulting from using maize starch as this wall material have higher viscosity when compared with maltodextrin was stated by Masters *et al.* (1991) and Jafari *et al.* (2008).

The solubility values of the different encapsulated flavour shows higher significant (P < 0.01) difference were indicated in Table 2. The findings indicated that different wall materials had effect on the solubility of the encapsulated flavour. FE 2 prepared with maltodextrin showed higher solubility in water when compared to FE 1 prepared with

modified starch. This may be due to different wall materials used for the encapsulation of flavour, also Barbosa *et al.* (2005) stated that maltodextrin had greater solubility when compared with modified starch.

Physico - chemical properties of different flavour encapsulated ice cream

There was no significant difference (P > 0.05) between pH, titratable acidity, fat, total solids and specific gravity values of different flavour encapsulated ice cream were recorded from the analysis of variance are indicated in Table 3. The

Table 3: Physico - chemical properties of different flavour encapsulated ice cream.

Parameter	Treatments			F value
	FEIC 0	FEIC 1	FEIC 2	
pH	6.46 ± 0.01	6.48 ± 0.19	6.45 ± 0.01	2.05
Titrateable acidity (%)	0.204 ± 0.02	0.206 ± 0.02	0.205 ± 0.00	0.21
Fat (%)	3.27 ± 0.80	3.17 ± 0.76	3.3 ± 0.12	0.54
Total solids (%)	37.17 ± 0.30	37.99 ± 0.21	38.06 ± 0.12	4.93
Specific gravity	1.112 ± 0.01	1.116 ± 0.01	1.113 ± 0.01	0.10
Viscosity (centi poise)	86.02 ^a ± 1.90	88.55 ^b ± 0.14	88.59 ^b ± 0.27	10.57*
Melting resistance (min)	28.79 ^a ± 0.41	36.03 ^c ± 0.57	31.22 ^b ± 0.88	73.42**

n = 6

** and * Different superscripts in the same rows differ significantly (P < 0.01) and (P < 0.05).

Table 4: Sensory evaluation of different flavour encapsulated ice cream.

Days	Treatments			F value
	FEIC 0	FEIC 1	FEIC 2	
Colour and appearance				
0 day	8.47 ± 0.84	8.43 ± 0.80	8.37 ± 0.61	0.45
3 rd day	8.40 ± 0.52	8.37 ± 0.61	8.40 ± 0.73	0.09
15 th day	8.40 ± 0.52	8.40 ± 0.73	8.26 ± 0.67	1.43
F value	0.36 ^{NS}	0.21 ^{NS}	1.07 ^{NS}	
Flavour				
0 day	8.80 ^{Bc} ± 0.52	7.17 ^{Aa} ± 0.12	7.13 ^{Aa} ± 0.84	112.43**
3 rd day	8.07 ^b ± 0.42	8.07 ^b ± 0.11	8.07 ^b ± 0.84	0.00
15 th day	7.20 ^{Aa} ± 0.84	8.83 ^{Cc} ± 0.11	8.17 ^{Bb} ± 0.10	70.34**
F value	154.64**	53.99**	41.76**	
Overall acceptability				
0 th day	8.60 ^{Bc} ± 0.52	7.27 ^{Aa} ± 0.84	7.23 ^{Aa} ± 0.61	134.51**
3 rd day	8.00 ^b ± 0.16	8.00 ^b ± 0.10	7.97 ^b ± 0.95	0.02
15 th day	7.20 ^{Aa} ± 0.89	8.63 ^{Bc} ± 0.80	8.37 ^{Bc} ± 0.12	60.35**
F value	39.64**	57.94**	36.26**	

n = 6 ** Different superscripts in the same rows differ significantly (P < 0.01).

above findings state that the encapsulated flavour and wall materials like maize starch, gum powder, carrageenan, maltodextrin and whey protein powder had no effect on the pH, titrateable acidity, fat, total solids and specific gravity values of the ice cream. These concurred with the findings of Verma (2002), Akesson (2008) and Pate (2011) who used maltodextrin, k - carrageenan and tapioca starch / whey protein concentrate in ice cream respectively in their study. However the titrateable acidity, fat, total solids and specific gravity values of the different flavour encapsulated ice cream were within the normal range as prescribed in BIS standards (IS: 2802, 1964).

Highly significant (P < 0.01) difference was noticed in the viscosity of different flavour encapsulated ice cream were indicated in Table 3. The increase in viscosity of different flavor encapsulated ice cream may be due to overall increase in stabilizing effect of these wall materials was noticed in the present study. These findings concurred to that of Alfaifi and Stathopoulos (2009) who used maltodextrin, k - carrageenan, corn starch and whey protein concentrate in ice cream respectively in their study. But the viscosity values

of different ice cream implied in the study were within the normal range as prescribed by De (1991).

The melting resistance values of different flavour encapsulated ice cream showed significant (P < 0.05) difference and are well within the normal range were indicated in Table 3. The highest melting resistance was noted in the FEIC 1. This may be due to greater stabilization effect of the maize starch, carrageenan and gum powder in ice cream was observed by BahramParvar *et al.* (2009) and the whey protein concentrate had significant effect on the melting resistance of the ice cream was also reported by Gray *et al.* (2008) and hence this may be the reason for having a lower melting resistance of FEIC 2 when compared with FEIC 1.

Sensory properties of different flavour encapsulated ice cream

Colour and appearance

The colour and appearance score of different flavour encapsulated ice cream on different treatment levels and varying period of study on the 0 day, 3rd day and 15th day did not differ significantly (P > 0.05) were indicated in Table 4.

Flavour

Highly significant ($P < 0.01$) difference was revealed between the flavour score of different flavour encapsulated ice cream on the 0 day. The highest flavour score was recorded in FEIC 0 on the 0 day. This lower flavour score in the FEIC 1 and FEIC 2 may be due to less mobility of flavour compound from the encapsulated material. These findings were in accordance to that of Gray *et al.* (2008) on the in vitro studies on the release profile of flavour. No significant ($P > 0.05$) difference between flavour score on 3rd day of different flavour encapsulated ice cream was evident from the analysis of variance. Highly significant ($P < 0.01$) difference was revealed between the flavour score of different flavour encapsulated ice cream on 15th day of storage period were indicated in Table 4. The FEIC 1 and FEIC 2 had the highest flavour score on 15th day. This indicates that the encapsulation has more influence on the retention and stability of flavour in ice cream. These findings are in accordance to the findings of Soottitantawat *et al.* (2005) who has stated that the retention and stability of the encapsulated compound may be due to moisture absorption by the wall materials and makes it rubbery and thus increase the release rate of the flavour compound.

Overall acceptability

Highly significant ($P < 0.01$) difference was revealed between the overall acceptability score of flavour encapsulated ice cream on 0 day. The highest overall acceptability scores were recorded in FEIC 0 on the zero day. No significant ($P > 0.05$) difference between overall acceptability score on 3rd day of flavour encapsulated ice cream were evident from the analysis of variance. Highly significant ($P < 0.01$) difference was revealed between the score of flavour encapsulated ice cream on 15th day were indicated in Table 4. Among different flavour encapsulated ice cream FEIC 2 had the highest overall acceptability score on 15th day of storage period. Thus, the flavour in ice cream had much influence on the overall acceptability of the ice cream. The retention and stability of flavour was higher in FEIC 1 and FEIC 2 and so the acceptability of the ice cream also increased when compared with FEIC 0.

CONCLUSION

Encapsulation of flavour has significant contribution in improving the flavour stability in ice cream. Further studies like slow release properties of encapsulated flavour compound before using in dairy products especially in ice cream where in flavour plays a major role. Percent incorporation also requires detailed studies so as to find out the adequate per-cent of incorporation in products would not have a negative effect on physicochemical, nutritive, textural and color characteristics of the end product. If appropriate techniques are used encapsulation can be a good revenue for producing novel dairy products. The greatest hurdle in the efficient utilization of this encapsulation technology is lack of infrastructure. Use of encapsulation

technique effectively can improve the retention of flavour and acceptability of the ice cream when compare to the regular ice cream. This encapsulation can be the promising technology for commercialization and more marketability of the dairy products.

REFERENCES

- Akesowan, A. (2008). Effect of combined stabilizer containing konjac flour and k- carrageenan on ice cream. *Aust. J. Tech.* 12(2): 81 – 85.
- Alamprese, C., Foschino, R., Rossi, M., Pompei, C. and Savani, L. (2002). Survival of *Lactobacillus johnsonii* La1 and influence of its addition in retail-manufactured ice cream produced with different sugar and fat concentrations. *International Dairy Journal*. 12: 201-208.
- Alfaifi, M.S and Stathopoulos, C.E. (2009). Effect of egg yolk substitution by sweet whey protein concentrate on some Gelato ice cream physical properties over storage. *J. Food. Nutr. Res.* 48(4): 183 – 188.
- AOAC. (2004). Official Methods of Analysis. The Association of Official Analytical Chemists. Arlington, US.
- Bahram Parvar, M., Haddadkhodaparast, M.H. and Razavi, S.M.A. (2009). The effect of *Lallemantia royleana* (Balangu) seed, palmate – tuber sleep and carboxymethylcellulose gum on the physicochemical and sensory properties of typical soft ice cream. *Int. J. Food. Sci. Tech.* 62: 571-576.
- Barbosa, M.I.M.J., Borsarelli, C.D. and Mercadante, A.Z. (2005). Light stability of spray dried bixin encapsulated with different edible polysaccharide preparations. *Food. Res. Int.* 38: 989 – 994.
- BIS. (1960). IS 1470. Indian Standards Institution, Manak Bhavan, New Delhi.
- BIS. (1964). Bureau of Indian Standard: 2802 Indian standard for ice cream. Indian Standards Institution, New Delhi.
- De, S. (1991). Outline of Dairy Technology, Oxford University Press, New Delhi, India, 405.
- Fernandes, R.V., Borges, S.V. and Borte, D.A. (2014). Gum arabic/ starch/maltodextrin/inulin as wall material on the micro-encapsulation of rosemary essential oil. *Carbohydr. Polymer.* 101: 524 – 532.
- Frost, M.B., Heymann, H., Bredie, W.L.P., Dijksterhuis, G.B. and Marten, M. (2005). Sensory measurement of dynamic flavour intensity in ice cream with different fat levels and flavourings. *Food. Qual. Prefer.* 16: 305-314.
- Gray, D.A., Bowen, S.E., Farhat, I. and Hill, S.E. (2008). Lipid oxidation in glassy and rubbery – state starch extrudates. *Food Chem.* 106(1): 227 – 234.
- Jafari, S.M., E. Assadpoor, Y.H. and Bhandhari, B. (2008). Encapsulation efficiency of food flavour and oils during spray drying. *Drying. Tech.* 26: 816-835.
- Karaman, S. and Kayacier, A. (2012). Rheology of ice cream mix flavoured with black tea or herbal teas and effect of flavouring on the sensory properties of ice cream. *Food. Bioproc. Tech.* 5: 3159 – 3169.
- Landy, P., Druaux, C. and Voilley, A. (1995). Retention of aroma compounds by protein in aqueous solution. *Food. Chem.* 54: 387 – 392.
- Madene, A., Jacquot, M., Scher, J. and Desobry, S. (2006). Flavour

- encapsulation and controlled release-a review. *International J. Fd. Sci and Technol.* 41: 1–21.
- Marshall, R.T., Goff, H.D. and Hartel, R.W. (2003). *Ice Cream*. 6th edition, Kluwer Acad / Plenum Pub. New York. 11-50.
- Masters, K. (1991). *Spray Drying Handbook*. 5th edition. Longman Scientific and Technical. Harlow. 616-617.
- Nedovic, V., Kalusevic, A., Manojlovic, V., Levic, S. and Bugarsk, B. (2011). An overview of encapsulation technologies for food applications. *Procedia. Food. Sci.* 1: 1806-1815.
- Pate, M., Pinto, S., Jana, A. and Aparnathi, K.D. (2011). Evaluation of stability of sago (Tapioca starch) as a functional ingredient in ice cream. *Indian. J. Fundamental. App. Life. Sci.* 1(2): 111-118.
- Santos, A.B. (2003). Encapsulation of the oleoresin paprika by atomization using gum Arabic and agglomerates of starch/gelatin: stability and applications, Ph.D. University of Estadual Campinas. Campinas, Brazil.
- Sommer, H.H. (1951). *The Theory and Practice of Ice Cream Making*. 6th Ed. Olsen Publishing Co. Melwakee. 155: 350-354.
- Soottitantawat, A., Takayama, K., Okamura, K., Muranaka, D., Yoshi, H., Furuta, T., Ohkawara, M. and Linko, P. (2005). Microencapsulation of l – menthol by spray drying and its release characteristics. *Innovat. Food. Sci. Emerging. Tech.* 6(2): 163 – 170.
- Stones, H. and Side, J.L. (1992). *Sensory Evaluation Practices*. 2nd edition: Academic Press, San Diego, 336.
- The British Standards Institution. (1975). *British standard glossary of terms relating to the sensory analysis of food*. British Standard Institution, London.
- Tomer, V. and Kumar, A. (2013). Development of high protein ice cream using milk protein concentrate. *J. Environ. Sci. Toxicol. Food. Tech* 6(5): 71-74.
- Turchiuli, C., Fuch, M., Bohin, M., Cuvelier, M.E., Ordonnaud, C., Mailard, M.N.P. and Dumoulin, E. (2005). Oil encapsulation by spray drying and fluidized bed agglomeration. *Innovat. Food. Sci. Emerg. Tech.* 6: 29-35.
- Verma, R.B. (2002). *Technological Studies on Manufacture of Frozen Dairy Desserts using Artificial Sweeteners*. Ph.D. thesis submitted to NDRI (Deemed University), Karnal.