IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 09 Issue 08, August 2022
ISSN (Online) 2348 – 7968 | Impact Factor – 6.72
www.ijiset.com

Effect Of Different Concentration Of Some Local Gums On The Physical Attributes Of Ice Cream

Ibtisam H. Elhassan[1], Elgasim Ali Elgasim[2], Eiman O. Basheer[1] and Ahmed Eltayeb Ismail Mohammed[1]

[1]Department of Animal Products/ National Food Research Center (NFRC)/ Khartoum north/ Sudan

[2]Department of Food Science and Technology, Faculty of Agriculture, University of Khartoum, Sudan

Mailing address: Ibtihuss@yahoo.com

Abstract:

The aim of this study was to examine the effect of adding some locally grown stabilizers on the overall quality of ice cream. Arabic gum (AG) (*Acacia Senegal)*, Guar (*Cyamoposis tetragonolba*) gum (GUG), Turtur (*Sterculia Setigira)* gum (TUG) and Talha (*Acacia Seyal)* gum (TAG) were screened to find a suitable replacer for the commercial stabilizers in ice cream production. Arabic gum, TUG and TAG were added to the ice cream mix at three concentrations 0.3, 0.5 and 0.7 % for each, while GUG was added at 0.1, 0.3 and 0.5% concentrations. Ice cream without gum was prepared as a control. The ice cream was manufactured in a batch manufacturing machine (Carpigiani), cooled, aged, hardened, packaged and stored at -18 ± 2ºC along with samples obtained from two factories for comparison. Physical characteristics were evaluated immediately after processing then after 1, 2 and 3 months of storage. Viscosity, overrun and melting resistance of ice cream were affected positively by type and concentration of gums. The highest values for viscosity (5123*cp*), overrun (35.65%) and melting resistance (24.7%) were observed in samples treated with gums when compared with the control 482.3*cp*, 25.04% and 18.98% respectively. Ice cream with Arabic gum, guar gum and turtur gum could be recommended for better physical characteristics and further research must be needed to study the another quality attributes.

Key words: Ice cream, Arabic Gum (AG), Tarter and Talha Physical, viscosity, overrun and melting resistance.

2- Introduction:

Livestock is the main agricultural resource in Sudan. Its population is 105 million heads, distributed throughout the country according to the climatic conditions (MLFR, 2015). However, milk production from these animals was estimated as 4391.000 tons (MLFR, 2015). Frozen desserts are among the most popular desserts eaten in or out the home. These include ice cream,

sherbets, and mousses (Peckham, 1974). Ice cream is a nutritionally enriched congealed dairy product consumed by all age groups particularly children, during summer (sharif *et al*, 2005). The main reason of ice cream quality deterioration is recrystallization. The outcome of recrystallization is the coarsening of ice cream, which makes ice cream icy and undesirable. Coarsening of ice crystals adversely affects the texture and shelf life. As a result, it is important to find a way to slow down the process so that customers can get the best quality products possible. Stabilizers are group of ingredients (usually polysaccharides), commonly used in ice cream formulation. Stabilizers are added to ice cream to slow down the rate of shrinkage. Added stabilizers increase the melting resistance of ice cream due to their water-holding and micro viscosity enhancement ability (Goff and Hartel, 2013). They perform several functions in ice cream such as the advantages of using stabilizers are to enhance smoothness of ice cream, slow down melting rate, prevent shrinkage of ice cream due to loss of moisture during storage, disguise the detection of ice crystal in ice cream during storage (Without the stabilizers, the ice cream would become coarse and icy very quickly due to the migration of free water and the growth of existing ice crystals (Han and Nguyen, 2014) and stabilize the foam structure of ice cream. Some common commercial stabilizers utilized in ice cream are sodium carboxyl methyl cellulose (CMC), locust bean gum (LBG), xanthan and so on. Besides, local hydrocolloids have also been used as ice cream stabilizers. For instance, salep serves as stabilizers in traditional ice cream in Iran and Turkey at 0.78-1.00% level (Kaya and Tekin, 2001). Available locally are many other stabilizers peculiar in various geographical locations. These include gum Arabic, guar gum, Turtur gum and Taleh gum. Most of the research work on gum in Sudan is directed to gum Arabic, while other gum of Sudanese origin received very little attentions (Hussein, 2006).

Objectives:

1. To determine the physical attributes of ice cream incorporated with Arabic Gum, guar, talha and turtur gums during storage period.
2. To select the best locally grown stabilizers to be used in the ice cream mix.

2- MATERIALS AND METHODS

2.1. Materials

Fresh whole cow's milk was obtained from University of Khartoum Dairy Farm (Halfaya). Whipping was obtained from DAL Dairy Factory (CAPO Products). Skim milk powder and vanilla powder were purchased from Omdurman market. Sucrose was purchased from local supermarket. Lecithin was obtained from Alrihab Factory, Omdurman. Stabilizers that were tried Gum arabic (*Acacia Senegal*), Tartar (*Sterculia setigera*) gum or gum karaya andTalha (*Acacia seyal*) gum were kindly provided by El Obeid agricultural Research Station, Kordofan, (ARC) Sudan and guar (*Cyamopsis tetragonoloba*) gum powder was kindly provided from the Sudanese Gum Arabic Company, Khartoum.

2.2 Methods

2.2.1 Preparation of stabilizer

Gum samples were dried at room temperature and cleaned by hand to remove foreign particles and adhering bark. The samples were then ground using a mortar and piston, sieved through sieve No. 4 and kept in glass containers.

2.2.2 Ice cream processing

2.2.2.1 Preparation of ice cream

Ice cream was produced as described by Balami *et al*. (2004) with slight modification.

2.2.2.2 Process of manufacturing

The processing steps for ice cream manufacturing include weighing and mixing, pasteurization, homogenization, cooling and ageing, freezing, hardening, packaging and storage.

i. accurately weighed dry ingredients were mixed with liquid ingredients by means of manual stirring for 10 minutes to get uniform mixture.

ii. Mix was pasteurized at 72ºC for 30 minutes in water bath as described by Marshall and Arbuckl (1996) to destroy pathogenic organisms and to check enzymatic activity.

iii. Mix was blended for two minutes in a domestic blender to check creaming and improving appearance of the ice cream.

iv. After blended the mix was cooled down to 4ºC immediately in a deep freezer and stored in a refrigerator at 4ºC overnight for about 24 h for ageing. Ageing increased the viscosity of the product. After ageing vanilla flavour was added.

iii. Ice cream was prepared with operating ice cream machine (a batch freezer). The freezer was rinsed with water and sanitized before freezing and between each treatment. The mix was frozen

at -5 to -6º C in the freezing chamber of electrically operated batch type ice cream machine, (that adds air, freezing the mix constantly for 20 minutes without). When the desired consistency was attained, ice cream was filled into sealed plastic cups. The cups were immediately transferred to the hardening unit maintained at -21ºC and the ice cream was kept for 24 hours. These cups were then transferred to deep freezers and (stored) at -18±2ºC.

3- RESULTS AND DISCUSSION

3.1 Viscosity

Viscosity is an important characteristic as it is required for achieving desirable whipping ability and retaining of air bubbles (Tarkashvand, 2005).

The viscosity of samples containing guar, Arabic, turtur and taleh gums was significantly increased ($p<0.05$) higher than that of the control (without gum) samples. Increasing the levels of all gums increased the viscosity. The lowest value for viscosity belonged to the control sample (81.3*cp*) and the highest to the sample containing 0.5% guar gum (5123*cp*). The viscosity of ice cream mixes before and after aging increased in guar, Arabic, turtur and taleh gum respectively. An increasing in concentration of stabilizers in ice cream causes an increased in viscosity (Moeenfard and Mazaheri, 2008). Stabilizers have water - holding capacity and can influence the rheological properties of ice cream mix (Guinard *et al*., 1994). Concerning the viscosity of the ice cream, so undoubtedly increase in quantity of stabilizers, result in increase in viscosity (Igoe, 1979; Muse and Hartel, 2004; Rosalina and Hartel, 2004). Higher viscosity in sample containing gums can be explained by the interaction of gums and liquid part of ice cream mix (Akalin and Erisir, 2008). Similarly Soukouls and Tzia (2008) showed that hydrocolloids such as carboxymethyl – cellulose, xanthan and guar could increase the viscosity of ice cream mixes. Increase in fat and milk protein may cause increase in viscosity (Tarkashvand, 2005).

3.2 Overrun:

The results presented in Table 2, indicated that the effect of using different type of gums as stabilizer in ice cream on the overrun. Type and concentration of gums had a significant effect ($p<0.05$) on overrun. The addition of gums had a significant effect ($p<0.05$) on the overrun of ice cream sample. The overrun value of ice cream ranged from 25.05% to 35.65%. Also results showed that in all samples overrun increased significantly with an increase in the concentration

of gums. More ever increasing concentrations of different gums improved the overrun of samples. Ice cream containing 0.5% guar gum and 0.7%turtur gum had a higher overrun values than other samples followed by Arabic gum and taleh gums respectively. The lowest value for overrun belonged to the control sample. Goff *et al*. (1989) and Goff (1995) indicated high concentration of nonfat milk solids (NMS) can increase overrun. In all samples, increase in concentration of gums and there for increase in viscosity improved overrun. Protein, fat and hydrocolloids are important for air incorporation (Marshall *et al*., 2003a, b). Ice cream with high concentration of hydrocolloids and there for high viscosity could trap air cells better than low - viscosity mixes that could not trap enough air. The results in this is study were in agreement with the results reported by Rezaei *et al*, (2011) who found that overrun range from 22.37% to 39.38%. Also result not far from the finding of Moeenfard and Tehrani, (2008) and AlaKali *et al.*, (2009) who found the range from 20.33% to 25.66%. however, finding in this study were in disagreement with those of Soad *et al*.(2014), Butt *et al* (1999), Thaiudom, *et al* (2008) who found the overrun ranged from (41.05% to 77.29%). The result contraster by over 80% value was given by Hui *et al* (2004). Akalin and Erisir, (2008) and Issariyachaikul (2008) reported low overrun values when using batch freezer. Rezaei *et al* (2011) also reported the low overrun due to using a batch type house hold ice cream maker. This could be attributed to the fact that home freezer was used instead of the usual standard scrapped surface heat exchanger. This may have affected drastically amount of air incorporated into the frozen mix (Alakali *et al*., 2009).

Table 1: Effect of local gums and storage period on Viscosity (for mix and ice cream

Treatment		**Viscosity(*cp*) (Mix)**	**Viscosity(*cp*)** (Ice cream)	**Over run (%)**
Gums	**Concentrations (%)**			
Guar	G1 (0.1)	725.7^{ef} ± 0.40	2488.3^{f} ± 0.23	31.80^{e} ± 0.02
	G2 (0.3)	883.3^{c} ± 0.90	3799.0^{c} ± 0.41	32.74^{c} ± 0.02
	G3 (0.5)	1934.3^{a} ± 0.72	5123.0^{a} ± 0.90	35.65^{a} ± 0.08
Arabic	A1 (0.3)	205.0^{j} ± 0.34	851.0^{k} ± 0.72	29.02^{j} ± 0.03
	A2 (0.5)	484.3^{g} ± 0.49	1812.3^{h} ± 0.64	30.84^{g} ± 0.02
	A3 (0.7)	741.3^{e}	3003.3^{e}	32.29^{d}

		± 0.40	± 0.11	± 0.02
Turtur	R1 (0.3)	716.3^{f} ± 0.44	2417.7^{g} ± 0.57	31.52^{f} ± 0.01
	R2 (0.5)	787.0^{d} ± 0.49	3486.7^{d} ± 0.66	32.22^{d} ±0.08
	R3 (0.7)	1011.0^{b} ± 0.36	5027.3^{b} ±0.18	34.43^{b} ±0.23
Taleh	T1 (0.3)	150.7^{k} ± 0.10	532.3^{l} ± 0.61	26.11^{k} ±0.34
	T2 (0.5)	222.3^{i} ± 0.37	915.7^{j} ±0.50	29.47^{i} ±0.32
	T3 (0.7)	438.7^{h} ± 0.68	1337.7^{i} ± 0.42	30.22^{h} ±0.17
Control	C (0%)	81.3^{l} ± 0.41	482.3^{m} ± 0.40	25.05^{l} ± 0.35

- Means ±SD
- Means with the same superscript letters in a column are not significantly different (P>0.05)

3.2 Melting resistance

Table 2, shows changes in melting resistance of ice cream during storage period as affected by stabilizes and different type of local gums with different concentration. Among all gum types taleh gum gave the lowest ice cream melting resistance (%) at all concentrations tested. When the gums were compared at equal gum concentration, 0.3% and 0.5% guar gum gave the highest ice cream melting resistance %. Results showed a direct correlation between results of this section and overrun as increase in overrun enhances melting resistance. Sakurai *et al* (1996), Sofajan and Hartel (2004), and Goff (1995) found that ice creams with low overruns melted quickly, whereas ice creams with high overruns began to melt slowly and had a good melting resistance. The use of konjack flour alone or combined with K-carrageenan as stabilizer retarded the meltdown of ice cream samples with respect to the control (Akesowan, 2008). Sakurai, *et al* (1996); Goff (1995) ; Rosalina and Hartel, (2004); Torabizade (2002) found and report that ice cream with lower overrun were harder than those made with high overrun but melted more rapidly. Stabilizers can form sticky network in yoghurt ice cream that result in more resistance to melting (El-Nagar *et al*., 2002). Sofjan and Hartel, (2004) also found that air acted as a good insulator, slowing the rate of heat transfer in ice cream and thus decreasing melting rate. A significant ($p<0.05$)

decreased in meltdown resistance of all samples of ice cream during 3 months of storage period were observed. These findings were in agreement with Guzeler *et al*, (2011); Singh *et al*, (2014); Butt *et al*, (1999); Murtaze *et al*, (2004b). Ozdemir *et al*. (2015) determined that melting down of samples was decreased during storage periods

Table 2: Effect of local gums and storage period on melting resistance (%) of ice cream

Treatments		Storage(days)					
Gums	**Concentration (%)**	**1**	**30**	**60**	**90**	**Treatment means**	
Guar	G1(0.1)	25.23^{f} ±0.07	24.35^{j} ±0.05	23.08^{o} ±0.06	21.93^{r} ±0.04	23.65^{AB}	24.7
	G2(0.3)	26.27^{b} ±0.05	25.44^{e} ±0.05	24.45^{i} ±0.05	23.25^{n} ±0.07	24.86^{AB}	
	G3(0.5)	26.89^{a} ±0.05	26.12^{c} ±0.06	25.22^{f} ±0.04	24.11^{k} ±0.04	25.59^{AB}	
Arabic	A1(0.3)	21.38^{u} ±0.05	20.24^{x} ±0.06	19.16^{z} ±0.05	18.77^{A} ±0.07	19.89^{EF}	21.94
	A2(0.5)	23.88^{l} ±0.06	22.68^{p} ±0.07	21.46^{tu} ±0.06	20.23^{x} ±0.06	22.07^{ABC}	
	A3(0.7)	25.47^{e} ±0.08	24.66^{h} ±0.06	23.28^{n} ±0.05	22.00^{r} ±0.07	23.86^{AB}	
Turtur	R1(0.3)	24.93^{g} ±0.06	23.10^{o} ±0.04	21.97^{r} ±0.06	20.93^{v} ±0.05	22.74^{ABC}	24.20
	R2(0.5)	26.11^{c} ±0.08	25.26^{f} ±0.04	24.36^{ij} ±0.04	23.11^{o} ±0.05	24.71^{AB}	
	R3(0.7)	26.84^{a} ±0.05	25.72^{d} ±0.05	24.60^{h} ±0.05	23.48^{m} ±0.07	25.16^{AB}	
Taleh	T1(0.3)	20.54^{w} ±0.05	19.30^{y} ±0.04	18.45^{B} ±0.06	17.89^{C} ±0.07	19.05^{F}	19.94
	T2(0.5)	21.55^{s} ±0.05	20.46^{w} ±0.07	19.32^{y} ±0.05	18.78^{A} ±0.08	20.03^{CD}	
	T3(0.7)	22.14^{q} ±0.06	21.50^{st} ±0.06	20.25^{x} ±0.05	19.13^{z} ±0.04	20.76^{BC}	
Control	(C)	20.28^{x} ±0.06	19.30^{y} ±0.09	18.45^{B} ±0.04	17.89^{C} ±0.04	18.98^{F}	18.98
Storage means		24.27^{A}	23.23^{B}	22.13^{C}	21.10^{D}		

- Means ±SD.
- Means with the same superscript letters are not significantly different (P>0.05).
- Means in the same row with the different superscript capital letters are significantly different (P≤0.05).

- Means in the same column with the different superscript capital letters are significantly different ($p \leq 0.05$).

Table 3: Effect of commercial stabilizers and storage period on melting resistance (%) of ice cream

	Storage(days)				
Treatments	**1**	**30**	**60**	**90**	**Treatment means**
Factory (F1)	23.17^{k} ±0.06	22.09^{i} ±0.05	21.02^{g} ±0.07	19.89^{d} ±0.02	21.54^{BC}
Factory (F2)	22.47^{j} ±0.07	21.61^{h} ±0.06	20.40^{f} ±0.05	19.28^{c} ±0.06	20.94^{BC}
Control (C)	20.28^{e} ±0.06	19.30^{c} ±0.09	18.45^{b} ±0.04	17.89^{a} ±0.04	18.98^{F}
Storage means	21.97^{A}	21.01^{B}	19.95^{C}	19.02^{D}	

- Means ±SD
- Means with the same superscript letters in a column are not significantly different ($P>0.05$)

4- CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

From the present study the following conclusions were drawn:

1. All gums had significant effects on the properties of ice cream.
2. Increasing the concentration of gums led to greater value of overrun.
3. Increasing the levels of all gums increased the viscosity.
4. Among all gum types taleh gum gave the lowest ice cream melting resistance (%) at all concentrations tested.
5. In general addition of local gums improves the physical characteristics of of ice cream.

4.2. Recommendations

1. Ice cream with Arabic gum, guar gum and turtur gum could be recommended for better physical attributes.
2. Further work should be conducted on ice cream to cover the following aspects:

a) Other locally available gums can be used to produce ice cream and to investigate their physicochemical and sensory properties.

b) Combination of locally gums which used as stabilizer and emulsifier can be used as an alternative to expensive imported stabilizers/emulsifier blends and can be used by small scale ice cream manufacture as well as larger ice cream industries.

c) Shelf life of ice cream should be determined.

d) Further research is needed to investigate the effect of different types of packaging (cartoon, plastic, foil with biscuit, etc..) on quality of ice cream.

REFERENCES:

Akalin, A. S. and Erisir, D. (2008*).* Effect of inulin and oligofructose on the rheological characteristics and probiotic culture survival in low fat probiotic ice cream.Journal of Food Science73:184-188.

Alakali, J.S., Okonkwo,T.M. and Uwu, L.U.(2009). Effect of food binders on the textual and sensory characteristics of ice cream. African Journal of Biotechnology, 8 (12): 2853-2856.

Akesowan, A. (2008). Effect of combined stabilizers containing konjac flour and k-carrageenan on ice cream. Australian Journal of Technology, 12 (2):81-85.

AOAC (2005). Official Methods of Analysis of the Association of Analytical Chemists International, 18th ed. Gathersburg, MD U.S.A Official methods, 2005.

Balami, Y.A., Bolaji, P.T., Hamza, F. and Bahago, E.J. (2004). Laboratory manual on food technology, nutrition and dietetics for schools and industries.Department of Food Technology, College of Science and Technology, Kaduna Polytechnic, Nigeria.

Butt, M.S., Ahmad, I., Mahmood, S. and Shahzadi, N. (1999). Effect of different combinations of stabilizers/emulsifiers on the quality of ice cream. Pakistan Journal Agricultural Sciences, 36:70-73.

El-Nagar, G., Clowes, G.,Tudorica, C.M., Kuri, V. *and* Brennan, C.S.(2002*).* Rheological quality and stability of yoghurt-ice cream with added inulin. International Journal of Dairy Technology55:89–93.

Guzeler, N., Kacar, A. and Say, D. (2011). Effect of milk powder, maltodextrin and polydextrose use on physical and sensory properties of low calorie ice cream during storage. Academic Food Journal, 9: 6-12.

Goff, H.D. and Jordan, W.K. (1989). Action of emulsifiers in promoting fat destabilization during the manufacture of ice cream. Journal of Dairy Science, 72:18–29.

Goff, H.D. (1995). Ice cream.Dairy Science and Technology at University of Guelph, Canada. Available from: http://www.foodsci.uoguelph.ca/dairyedu/icecream.html. Accessed: Nov. 20. 2006.

Goff, H. D. and Hartel, R. W. (2013). Ice Cream.7th Ed. Springer New York Heidelberg Dordrecht London.

Guinard, J.X., Little, C., Marty, C. and Palchak, T.R. (1994). Effect of sugar and acid on the acceptability of frozen yogurt to a student population. Journal of Dairy Science, 77: 1232-1238.

Han, H. N. and Nguyen, K. K. (2014). Effect of ice crystal size on the textural properties of ice cream and sorbet. A major qualifying project proposal submitted to the Faculty of the Worcester Polytechnic Institute.

Hussein, M. S. (2006). Comparative study on some Sudanese gums: Hashab (*Acacia Senegal*), talha (*Acacia seyal*) and karaya (*Sterculia setigera*). M.Sc. Thesis, Faculty of Science, Uniersity of Kordofan.

Igoe, S. R. (1979). Compositions for stabilizing soft serve and hard frozen yoghurt. United states Patent.

Issariyachaikul, K.(2008). Development of modified fat ice cream products using inulin as a fat replacer.Thesis, Faculty of Graduate Studies, Mahidol University.

Kaya, S. and Tekin, A.R. (2001). The effect of salep content on the rheological characteristics of a typical ice cream mix. Journal of Food Engineering, 47: 59–62.

Marshall, R.T. (1991). Fat in ice cream.Dairy Field.74: 32.

Marshall, R.T. and Arbuckle, W.S. (1996). Ice cream, 5th Edition. Chapman and Hall, New York.Int. Thompson Publ, New York, 263–268.

MLFR (2015). Ministry of livestock, Fishenes and Rangelands, department of Statistic and Information, Khartoum - Sudan.

Moeenfard, M.andMazaheri, T.M.(2008). Effect of some stabilizers on the physicochemical and sensory properties of ice cream type frozen yoghurt. American-Eurasian Journal of Agriculture and Environment Science4(5):584–589.

Murtaza, M.A., Huma, G.N., Din, M.U., Shabbir, M.A. and Mahmood, S.D. (2004a). Effect of fat replacement by fig addition on ice cream quality. International Journal of Agriculture and Biology, 6:68–70.

Murtaza, M.A., Mueen, G.U., Nuzha,T.H., Asim, S. and Shahid, M. (2004$_b$). Quality evaluation of ice cream prepared with different stabilizers/emulsifier blends, International Journal of Agriculture and Biology, 1: 65–67.

Muse, M.R. and Hartel, R.W. (2004). Ice cream structural elements that affect melting rate and hardness. Journal of Dairy Science, 87: 1–10.

Ozdemir, C., Arslaner, A., Ozdemir, S. and Allahyari, M. (2015). The production of ice cream using stevia as a sweetener. Journal of Food Science and Technology, 52(11): 7545-7548.

Peckham, G. (1974). Foundations of food preparation, 3rd ed. Macmillan Publishing Co., Inc.New York and London.

Rezaei, R., Khomeiri, M., Kashaninejad, M. and Aalami, M. (2011). Effects of guar gum and arabic gum on the physicochemical, sensory and flow behavior characteristics of frozen yoghurt. International Journal of Dairy Technology, 64(4): 563-568.

Rosalina, P.S. and Hartel, R.W. (2004). Effects of overrun on structural and physical characteristics of ice cream.International Dairy Journal. 14 (3): 255-262.

Sakurai, K., Kokub, S., Hakamata, K., Tomita, M. and Yoshida, S. (1996). Effect of production conditions on ice cream melting resistance and hardness. Milchwissenschaft, 51(8): 451 -454.

Sharif, N., Ghanghesh, K.S., Gnan, Y.A.S. and Rahouma, A. (2005). Bacteriological quality of ice cream in Tripoli-Libya.Food Control, 17: 637- 641.

Singh, J., Bajwa, U. and Goraya, R.K. (2014). Effect of storage period on the physicochemical, sensory and microbiological quality of bakery flavoured ice cream . International Journal of Engineering Research and Applications, 4(5): 80-90.

Sofjan, R. P. and Hartel, R. W. (2004). Effects of overrun on structural and physical characteristics of ice cream. International Dairy Journal, 14: 255-262.

Soukoulis, C.andTzia, C.(2008). Impact of the acidification process, hydrocolloids and protein fortifiers on the physical and sensory properties of frozen yoghurt. International Journal of Dairy Technology61:170–177.

Tarkashvand, Y. (2005). Ice cream. Tehran. Ata publisher (in Persion) C.F. Rezaei et al. 2011.

Thaiudom, S., Singchan, K. and Saeli, T. (2008). Comparison of commercial stabilizers with modified tapioca starches on foam stability and overrun of ice cream. Asian Journal of Food and Agro-Industry. 1(01): 51-61.

Torabizade, H. (2002). Food emulsions and emulsifiers, Aeij Publisher, Tehran.