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Organoleptic Evaluation of Ice Cream with a Fuzzy Logic Approach

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Abstract

Ice cream is the most popular frozen dessert sold worldwide and the role of its consumer acceptance is vital. The increasingly growing demand for ice cream each year demands the larger production of ice cream both at large as well as small scale. Therefore, proper quality control of ice cream obtained from each of the freezing methods should be maintained. For this, the ice cream that is available commercially was compared with those obtained from the cryogenic freezer and direct liquid nitrogen (LN2) infusion technique using the fuzzy logic approach. The acceptability of ice cream samples was judged based on the quality attributes like viscosity, texture, flavor, overrun, and overall acceptability. After finding out the similarity values, the quality attributes were ranked as Texture > Overrun > Overall acceptability > Viscosity > Flavor w.r.t to the freezing technique applied. Also, the ice cream that is available commercially and cryogenically frozen ice cream was much more acceptable than the LN_2 infusion method.

Keywords: Ice cream; Fuzzy; Quality attributes; Freezing; Similarity values

Introduction

Ice cream is a frozen dessert that is consumed worldwide and the demand for it depends mostly upon its quality parameters. Consumer acceptance is the utmost priority for successfully running a business. A good quality ice cream should be rich in taste, must have good body and texture, and a desirable amount of overrun and viscosity. All of these parameters play an important role while judging the overall acceptability of ice cream. Due to the growing demand for ice cream worldwide, the production of ice cream is carried out on a small scale as well as on a large scale. There are various types of mechanical refrigerators, cryogenic freezers, and other freezing techniques available in the market that is used for producing ice cream [1]. The quality parameters of ice cream are judged by comparing the sensory characteristics of ice cream from one that is available commercially, produced from a cryogenic freezer, and one that is directly produced by the infusion of Liquid Nitrogen (LN_2) in ice cream mixture which is the most popular method for small scale production in most parts of the world. The quality of the end product differs significantly by changing the freezing method or technique. The freezing techniques greatly affect the ice crystal size distribution and structural development in ice cream. It affects various properties like textural and body characteristics, viscosity, overrun, etc.

There are various evaluation methods used to estimate the consumer acceptance of the product and to rank the importance of various quality attributes concerning each product. Sensory evaluation is one such method for the quality control of the product. The researcher's focus from the last few years has increased greatly on the implementation of fuzzy logic in quality control for various food industries. Das [2] had elaborated on the applications of fuzzy logic in various food materials. Fuzzy logic is an important decision-making tool for the comparison of various quality parameters of the developed product. The reasoning process of sensory evaluation is expressed in terms of linguistic operators and experts [3]. Thus, for this type of problem where the information is uncertain and fuzzy, linguistic decision analysis can be carried out to model and manage [4]. In fuzzy modeling, the linguistic variables like "poor, fair, medium, good, and excellent" are used, and based on liking and disliking ranking of each quality attribute under each product is done. Each product is assigned quality attributes like texture, flavor, viscosity, and overrun, and the fuzzy logic approach can assist in finding the preference level of each quality attribute. The order of preference of each quality attribute can be decided by assigning them linguistic entities like "Not important, somewhat important, important, highly important and extremely important". In the case

of a newly developed product, fuzzy logic also helps in decision-making related to the acceptance or rejection of the product [5].

In this research article, the ice cream that is available commercially, cryogenically frozen ice cream, and ice cream produced from the LN_2 infusion technique are compared for their sensory characteristics. The sensory parameters of each sample were compared using fuzzy logic approach and a method based on simple mathematical calculations was applied.

Materials and Methods

Preparation of Different Ice Cream Samples

Total 3 samples were gone through sensory evaluation. The first one was good to average commercial ice cream, the approximate composition of which is given in Table 1. For the preparation of the second and third samples, the ice cream mixture was formulated to contain the same composition as given in table 1. For this, a simple arithmetic rule was applied to calculate the amount of each ingredient required to prepare the ice cream mixture of the same composition. To prepare the mixture Amul Taza Homogenized toned milk having 3% fat and 8.5% MSNF, and Amul Fresh cream having 25% fat and 3.4% MSNF was used. Skim Milk Powder (SMP) with 1.5% fat and 96% MSNF was used to get desired total solid concentration in ice cream. The whole milk was initially blended with granulated sugar (purchased from the local market) and skim milk powder (SMP, Loba Chemie Pvt. Ltd. Mumbai, MH). The cream was then whipped with the commercial blender to give the ice cream a smooth texture and creamy taste and was added to the initially blended mixture of whole milk, sugar, and SMP. After this, Tween 80 (Polyoxyethylene sorbitan monooleate) (Merk Specialities Pvt. Ltd. Mumbai, MH) whose density varies from 1.06 to 1.09 gm/ml, and Gelatin powder (Loba Chemie Pvt. Ltd. Mumbai, MH) was added to the mixture. The mixture was then gently stirred for a uniform mix and kept in an ice bath to cool down. After this, the ice cream mix was placed in a deep freezer for aging at 4 ºC for overnight (24 hrs). (Table 1)

Table 1: Approximate composition of commercially available ice cream.

Milk Fat	Milk Solid Not Fat (MSNF)	Sugar	Stabilizer and Emulsifier	Total solids
12%	11%	15%	0.30%	37-39%

After preparation of the ice cream mixture, it is frozen by a cryogenic freezer and by the direct infusion of LN_2 in the mixture. For freezing of ice cream by LN_2 infusion method, an ice cream maker was used which is having the capacity of 5 liters. It consists of a planetary motion mixer in which there is a rotation of planetary blades on their own axis in addition to the rotation around the center of the mixing bowl. The speed of the rotor was kept constant throughout the experiment. Ice cream was poured into the bowl and the mixer was started. After this, LN_2 was directly infused in the ice cream mixture and continuously stirred. The liquid nitrogen is inert, non-toxic, and extremely cold having a boiling point of -196 ºC (-320 ºF). The extremely low temperature of LN_2 and substantial temperature difference between the product and LN_2 results in quick freezing and formation of very small ice crystals in the resultant ice cream. After freezing from the cryogenic freezer and by LN_2 infusion technique, frozen ice cream samples were kept at a temperature below -20 ºC until the temperature of ice cream reaches -18 ºC.

Selection of Panelists and Sensory Evaluation

By application of the fuzzy logic model, sensory properties of commercially available ice cream were compared with the ice cream frozen from the cryogenic freezer and LN_2 infusion. Therefore, 3 samples were analyzed using the fuzzy logic approach and were coded as Ic1 (Commercially available ice cream), Ic2 (Ice cream prepared from a Cryogenic freezer), and Ic3(Ice cream prepared from LN2 Infusion). Total 10 panelists of good health having good ability to concentrate and analyze the sensory property of ice cream from the Department of Agricultural and Food Engineering, IIT Kharagpur was selected to carry out the sensory analysis. The norms of the American Society for Testing and Materials (ASTM) [6,7] were followed during the sensory evaluation of each sample. They were provided with the datasheet (Appendix I) in which they had to tick mark (✓) under each quality attributes based on their liking and disliking and had to rate them as "poor, fair, medium, good and excellent". The quality attributes that were selected include *Viscosity, Texture, Flavor, Overrun, and Overall acceptability* (OA). For finding out the quality attributes ranking of ice cream in general, the linguistic variable that was selected includes: "Not important, somewhat important, important, highly important and extremely important". Ranking of all the ice cream samples was done using the triangular membership distribution function.

Analysis of Sensory Data Using Fuzzy Logic Approach

Analysis of sensory data and to find out the similarity values, there are 5 major steps involved which includes:

I. Calculation of sensory scores of each sample under each quality attributes in the form of triplets.

II. Calculating sensory scores of each quality attribute in general and finding out their relative weightage in the form of triplets (viz., QV_{rel}, QT_{rel}, QF_{rel}, QOR_{rel}, QOA_{rel}).

III. Calculation of overall sensory scores (viz., S_1O, S_2O, and S_3O)of each sample in the form of triplets.

IV. Converting five-point linguistic scale to six-point standard fuzzy scale (viz., F1, F2, F3, F4, F5, and F6) and finding

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out ten numbered overall membership function values (viz., B1, B2, and B3) of each sample.

V. Finding out the similarity values and ranking of each sample and also quality attribute in general.

Sensory scores of the samples under each quality attributes in the form of triplets

"Triplets" are the set of three numbers that represent the distribution pattern of triangular membership function in 5 point sensory scales as shown in Table 2.

Table 2: Triplets associated with sensory scales.

Poor/ Not important			Fair/ Somewhat important			Medium/ Important			Good/ Highly important			Excellent/Extremely important		
0	0	2.5	2.5	2.5	2.5	5	2.5	2.5	7	2.5	2.5	10	2.5	0

The first number of the triplet indicates the value of abscissa where the value of membership function is one; the second number indicates the distance between the first number of the triplet and the left side where the value of membership function is zero; the third indicates the distance between the first number of the triplet and the right side where the value of membership function is zero (Figure 1). For example, in figure 1, the triangle "cd1e" represent the membership function under the category 'Fair/Somewhat Important' where triplets are (5 2.5 2.5) where the first number i.e. 5 denotes a value of abscissa where the value of membership function is one and next two number numbers i.e., 2.5 and 2.5 indicates the distance between the first number of the triplet to the left side and right side of the triangular distribution pattern, where the value of membership function is zero, respectively.

After this average sensory score of all the samples under each quality, attributes can be calculated using equation 1 which is given as

$$S_x Y = \frac{b(0\ 0\ 2.5) + c(2.5\ 2.5\ 2.5) + d(5\ 2.5\ 2.5) + e(7.5\ 2.5\ 2.5) + f(10\ 2.5\ 0)}{T} \quad (1)$$

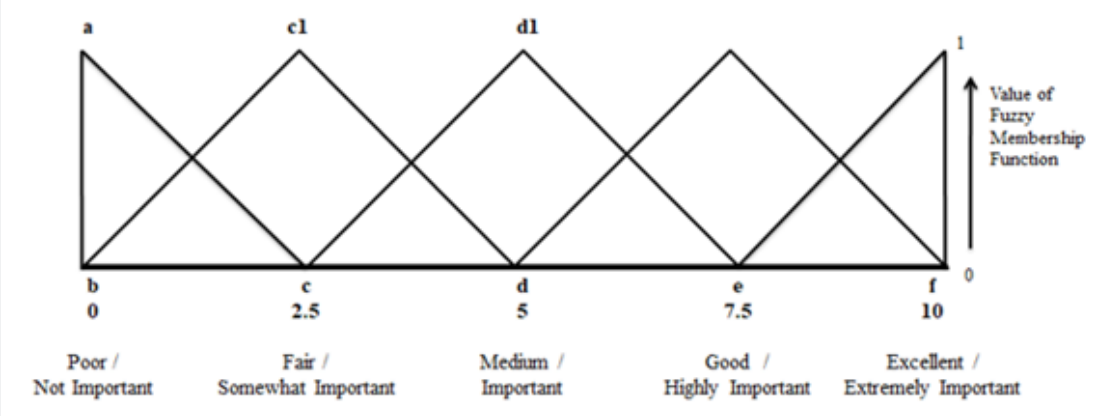

Figure 1: Schematic representation of triangular membership distribution function for five-point sensory scales and triplets associated with it

Where 'x' is the sample number, 'Y' is the quality attribute and 'T' is the total number of panelists. 'b' is the number of panelists who ranked the sample as 'poor' under that particular quality attribute. Similarly, c, d, e, and f are the number of panelists given fair, medium, good and excellent, respectively. The sensory scores will come out in the form of triplets.

Sensory scores of each quality attribute in general and their relative weightage

The average sensory score of each quality attribute, in general, can be calculated using equation 2. In this case, b, c, d, e, and f are the number of panelists given 'not important', 'Somewhat Important', 'Important', 'Highly important' and 'Extremely important, respectively.

$$Q\_Y = \frac{b(0\ 0\ 2.5) + c(2.5\ 2.5\ 2.5) + d(5\ 2.5\ 2.5) + e(7.5\ 2.5\ 2.5) + f(10\ 2.5\ 0)}{T} \quad (2)$$

Where 'Q' is quality, 'Y' is the quality attribute and 'T' is the total number of panelists. The relative weightage of each quality attribute (QY_{rel}) can be found out as the ratio of an average sensory score of each quality attribute and the sum of the first digit of all the quality attributes (Qsum). According to Routray& Mishra [8], the relative weightage of each quality attribute will always be the average sensory score divided by the sum of the first digit of the triplet.

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Calculation of overall sensory scores

Overall Sensory scores can be found out by the sum of the product of the average sensory score of sample in the form of triplet and relative weightage for each quality attribute and can be given as

$$SxO = SxV \times QVrel + SxT \times QTrel + SxF \times QFrel + SxOR \times QORrel + SxOA \times QOArel \quad (3)$$

Where 'x' is the sample number, 'V' stands for viscosity, 'T' stands for Texture, 'F' stands for Flavor, 'OR' stands for overrun and 'OA' stands for Overall acceptability. The multiplication of the triplets associated with the average sensory score of the sample with triplet associated with the relative weightage of each quality attribute follows a certain multiplication rule. For example, (a,b,c) are triplets associated with the average sensory score of the sample, and (d,e,f) is the triplet associated with the relative weightage of each quality attribute, then

$$(a,b,c) \times (d,e,f) = (a \times d \quad a \times e + d \times b \quad a \times f + d \times c) \quad (4)$$

After this, we will get the overall sensory for the samples Ic1, Ic2, and Ic3.

Calculating overall membership function value

After finding out the overall sensory scores of each sample, 5 point linguistic scale is converted to 6 points standard fuzzy scale. Figure 2 shows the triangular distribution pattern of 6 point standard fuzzy scale. (Figure 2)

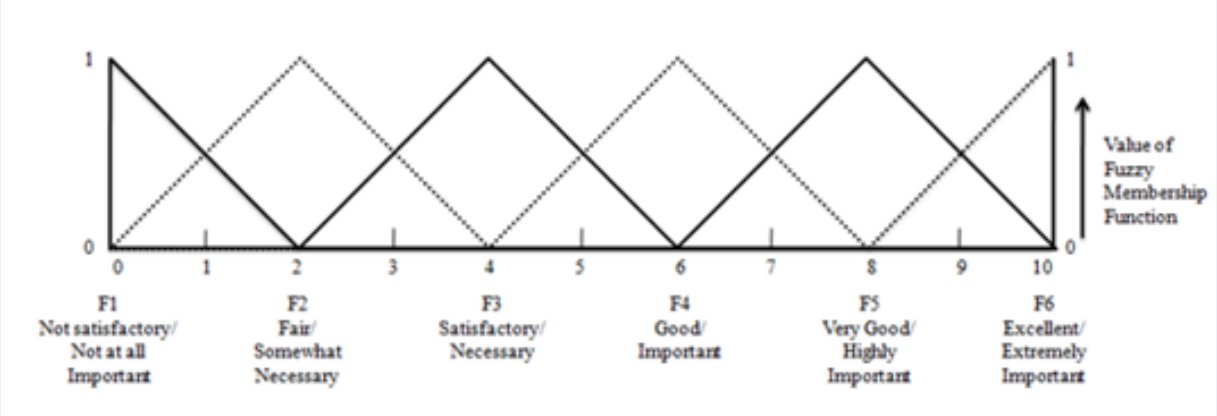

Figure 2: Schematic Representation of Triangular Distribution on Standard Fuzzy Scale.

F1, F2, F3, F4, F5, and F6 are membership functions in a standard fuzzy scale. Each membership function is the set of 10 numbers which is given in Table 3. Each membership function defines a particular linguistic variable.

Now, to find out overall membership function values i.e., B1, B2, and B3 for each sample, graphical representation (Figure 3) were used which is indicating the membership function of the triplet. In the figure, we can see the triangle ABC representing the triangular membership function. Now, the overall membership function of each sample will be represented by a set of ten numbers. For this, it will be considered that, when the value of abscissa is less than (a - b) or greater than (a + c), the value of membership function is 0; whereas, when the value of abscissa is equal to 'a', then the value of membership function is 1. Mathematically, it can be represented as

$$Bx = 0 \text{ when } x < (a - b) \text{ or } x > (a + c);$$
$$B\_x = (x - (a - b)) / b \text{ when } (a - b) < x < a;$$
$$B\_x = ((a + c) - x) / c \text{ when } a < x < (a + c) \quad (5)$$

The value of Bx for each sample's triplets are calculated at x = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. The value of the overall membership function is the maximum value between 10 intervals from 0 to 10 and can be calculated using equation 5**.** (Figure 3)

Calculation of similarity values of ice cream samples and all quality attributes along with their ranking

After finding out the overall membership function of all three ice cream samples, similarity values of each sample can find out using equation 6 [9].

$$S\_m\{F,B\} = \frac{(F \times B\hat{}T)}{Max\{F \times F\hat{}T \text{ and } B \times B\hat{}T\}} \quad (6)$$

$S_m\{F,B\}$ denotes the similarity value which is a function of F and B. FT and BT is the transpose of F and B, respectively. Once all the similarity values under a different category (Table 3) were calculated on the standard fuzzy scale for each sample, the category getting the highest score will define that particular sample/quality attribute. In the final stage, ranking of each sample/quality attribute was done based on their values on a standard fuzzy scale.

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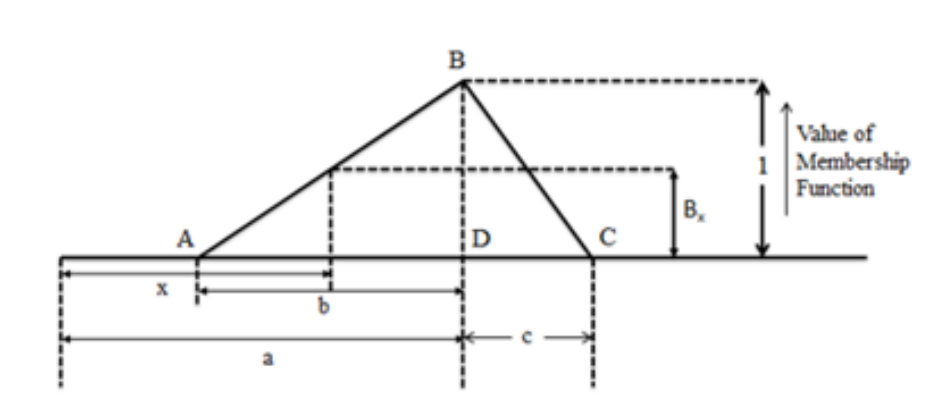

Figure 3: Graphical illustration of triplet in the form of triangle membership function.

Results and Discussion

Fuzzy Analysis of Ice cream samples and their quality attributes

Table 4 shows the number of panelists who had given their rating in terms of linguistic variables like "poor, fair, medium, good, and excellent" to the ice cream that is available commercially, cryogenically frozen, and infused with LN2. The triplets were calculated using equation 1. Similarly, the number of panelists who considered quality attributes like viscosity, texture, flavor, overrun, and overall acceptability as "not important, somewhat important, important, highly important, extremely important" are shown in table 5 and their triplets were calculated similarly. The relative weightage of all the quality attributes is also given in Table 5.

Table 3: Membership function on standard fuzzy scale.

F1	{1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0}	Not satisfactory/ Not at all important
F2	{0.5, 1, 1, 0.5, 0, 0, 0, 0, 0, 0}	Fair/ Somewhat necessary
F3	{0, 0, 0.5, 1, 1, 0.5, 0, 0, 0, 0}	Satisfactory/ necessary
F4	{0, 0, 0, 0, 0.5, 1, 1, 0.5, 0, 0}	Good/ Important
F5	{0, 0, 0, 0, 0, 0, 0.5, 1, 1, 0.5}	Very Good/ Highly Important
F6	{0, 0, 0, 0, 0, 0, 0, 0, 0.5, 1}	Excellent/ Extremely Important

Table 4: Number of judges (total 10) based on their preference rating and triplets associated with the sensory scores under each quality attribute of different sample.

Sensory Quality Attributes		Poor	Fair	Medium	Good	Excellent	Triplets for sensory scores		
Viscosity	Commercially available IC (vanilla flavor)	0	0	2	5	3	7.75	2.5	1.75
	IC from cryogenic freezer	0	0	1	6	3	8	2.5	1.75
	LN2 infused IC	0	4	6	0	0	4	2.5	2.5
Texture	Commercially available IC (vanilla flavor)	0	0	1	6	3	8	2.5	1.75
	IC from cryogenic freezer	0	0	1	5	4	8.25	2.5	1.5
	LN2 infused IC	0	6	4	0	0	3.5	2.5	2.5
Flavor	Commercially available IC (vanilla flavor)	0	1	3	6	0	6.25	2.5	2.5
	IC from cryogenic freezer	0	1	2	7	0	6.5	2.5	2.5
	LN2 infused IC	0	2	3	5	0	5.75	2.5	2.5

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Overrun	Commercially available IC (vanilla flavor)	0	0	2	6	2	7.5	2.5	2
	IC from cryogenic freezer	0	0	1	6	3	8	2.5	1.75
	LN2 infused IC	0	0	3	6	1	7	2.5	2.25
Overall accept-ability	Commercially available IC (vanilla flavor)	0	0	2	5	3	7.75	2.5	1.75
	IC from cryogenic freezer	0	0	2	5	3	7.75	2.5	1.75
	LN2 infused IC	0	4	4	2	0	4.5	2.5	2.5

Table 5: Number of judges with different preferences on quality attributes, triplets associated with scores, and the relative weightage for quality attributes of the samples in general.

Quality attributes of the sample in general	NI	SI	IMP	HI	EI	Triplets for sensory scores			Triplets for the relative weightage
Viscosity	0	0	6	3	1	6.25	2.50	2.25	QV_{rel} = (0.189 0.076 0.068)
Texture	0	0	1	4	5	8.50	2.50	1.25	QT_{rel} = (0.258 0.076 0.038)
Flavor	0	7	3	0	0	3.25	2.50	2.50	QF_{rel} = (0.098 0.076 0.076)
Overrun	0	0	1	2	7	9.00	2.50	0.75	QOR_{rel}=(0.273 0.076 0.023)
Overall acceptability	0	2	3	4	1	6.00	2.50	2.25	QOA_{rel}=(0.182 0.076 0.068)

*NI = not important; SI = somewhat important; IMP = important; HI = highly important; EI = extremely important

After this, the overall sensory scores were calculated using the procedure mentioned in section 2.3.3 and for each sample sensory scores come out in the form of triplets which is given in table 6. Using equation 5, the value of B's for all the samples was also found out as shown in table 7. After attaining the F and B values, transpose of them was found out and equation 6 was used to finally get the similarity values of the sample on the standard fuzzy scale. A similar procedure was followed to find out the similarity value of the quality attribute. (Table 6-7)

Table 6: Overall Sensory Scores of the Ice cream Samples.

S_1O	7.59925	5.331	3.89725
S_2O	7.872	5.426	3.8215
S_3O	4.9525	4.381	3.74075

Table 7: Overall membership function (B) of the Ice cream samples.

Overall membership function	Values									
B1	0.0000	0.0000	0.1373	0.3248	0.5124	0.7000	0.8876	1.0000	0.6406	0.3840
B2	0.0000	0.0000	0.1021	0.2864	0.4707	0.6550	0.8393	1.0000	0.7048	0.4432
B3	0.0978	0.3261	0.5543	0.7826	1.0000	0.7200	0.4527	0.1853	0.0000	0.0000

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Ranking of Ice cream Samples and their quality attributes

Similarity values of different ice cream samples are given in Table 8, based on which ranking has to be done. Figure 4(a) represents the similarity values of each sample in the radar plot. In the case of commercially available ice cream, the highest similarity value attained was 0.7273 which corresponds to the Good (F4) category on the standard fuzzy scale; for cryogenically frozen ice cream, the highest similarity value was 0.7469 and it is coming in the standard fuzzy scale range of Very Good (F5); and in case of LN_2 infused ice cream, highest value achieved was 0.8665 which lies in the scale range of satisfactory (F3). Based on this, a ranking of individual samples was done and cryogenically frozen ice cream was given rank I while commercially available ice cream and LN2 infused ice cream were ranked II and III, respectively. The reason for this is that in the case of ice cream that was prepared from a cryogenic freezer, there was a larger temperature difference between cryogenic liquid and ice cream mix, which resulted in the formation of the smaller amount of ice crystals, which improves its textural and surface properties and results in much creamier and smoother ice cream. Therefore, it was found out that, IC from the cryogenic freezer (Very Good) > commercially available IC (Good) > LN_2 infused IC (satisfactory). Also, by closely looking at the similarity values it is clear that similarity values of cryogenically frozen ice cream are very close to similarity values of commercially available ice cream. Therefore, it can be said that ice cream obtained from a cryogenic freezer closely resembles ice cream available commercially in terms of the panelist's choices. (Table 8)

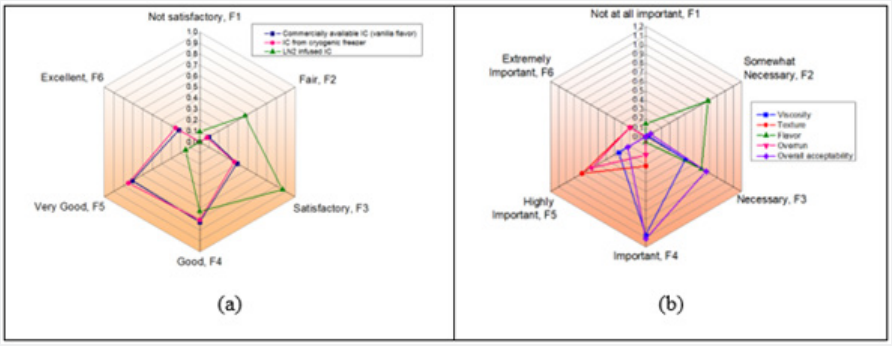

Figure 4: Graphical representations of the similarity values obtained for (a) ice cream samples (b) quality attributes.

Table 8: Similarity values and ranking of the ice cream samples.

Scale Factor	Commercially available IC (vanilla flavor)	IC from cryogenic freezer	LN_2 infused IC
Not satisfactory, F1	0	0	0.0934
Fair, F2	0.0931	0.0780	0.4730
Satisfactory, F3	0.3897	0.3617	**0.8665**
Good, F4	**0.7273**	0.7100	0.6319
Very Good, F5	0.7062	**0.7469**	0.1475
Excellent, F6	0.2184	0.2534	0
Ranking	**II**	**I**	**III**

To check the importance of selected quality attributes concerning the fuzzy analysis carried out for ice cream samples, similarity values were calculated as shown in Table 9. Graphical representation of same is shown in Figure 4(b). The highest similarity values obtained were in the case of texture (0.8) and overrun (0.68) which lies in the standard fuzzy scale category of Highly Important (F5). Viscosity (1.067) and Overall Acceptability (1.110) have the maximum similarity value in the category Important (F4) while Flavor has the maximum similarity value in the category Somewhat Necessary (F2). From the values obtained, it was found that texture, overrun and viscosity plays an important role in the overall acceptability of ice cream. The sensory attributes like texture are also related to viscosity as viscosity clearly influences the mouthfeel which depends on the body and textural property. Overrun affects the amount of air incorporation and makes the ice cream more fluffy. The reason that flavor was considered less important as compared to other quality attributes is that all the three ice cream samples were of the same flavor (vanilla) and there is no or very little effect of the freezing technique on the flavor of ice cream. Therefore, the acceptability of ice cream by the consumer is mainly perceived by texture, viscosity, and overrun. From the results obtained, it was found that Texture > Overrun > Overall acceptability > Viscosity > Flavor and therefore, it was ranked accordingly. (Appendix I)

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Table 9: Similarity values and ranking of quality attributes.

Scale Factor	Viscosity	Texture	Flavor	Overrun	Overall acceptability
Not at all important, F1	0	0	0.14	0	0
Somewhat Necessary, F2	0.0236	0	**0.78**	0	0.0581
Necessary, F3	0.4955	0	0.70	0	0.7558
Important, F4	**1.0670**	0.32	0.06	0.2	**1.1110**
Highly Important, F5	0.3407	**0.8**	0	**0.68**	0.2262
Extremely Important, F6	0	0.2	0	0.2	0
Ranking	**IV**	**I**	**V**	**II**	**III**

Appendix I

Fuzzy Logic Score Card For Sensory Evaluation of Different Ice Cream Samples

Product _____ Made on_____

Tested on_____

Please rate the sample for quality attributes by putting (✓) mark against the appropriate grade

Quality Attributes	Sample	Poor	Fair	Medium	Good	Excellent
Viscosity	**Ic1**					
	Ic2					
	Ic3					
Texture	**Ic1**					
	Ic2					
	Ic3					
Flavor	**Ic1**					
	Ic2					
	Ic3					
Overrun	**Ic1**					
	Ic2					
	Ic3					
Overall Acceptability (OA)	**Ic1**					
	Ic2					
	Ic3					

Please indicate the weightage you would like to assign for each quality attribute of cupcake in general by putting (✓) mark against the appropriate grade

Quality Attributes	Not Important	Somewhat Important	Important	Highly Important	Extremely Important
Viscosity					
Texture					
Flavor					
Overrun					
Overall Acceptability (OA)					

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Conclusion

The present study demonstrates the fuzzy logic approach for the quality acceptance of ice cream obtained from various freezing techniques. Fuzzy logic is an important tool that was efficiently applied in the present study for ranking the acceptability of ice cream obtained from different freezing sources. A similar approach was applied to rank the individual quality attributes in general. Based on the similarity values obtained, the quality attributes were ranked as Texture > Overrun > Overall acceptability > Viscosity > Flavor. It was found that texture and viscosity are interrelated as viscosity influences the mouthfeel which depends upon the surface and textural properties. Based on the rating given by panelists, it was found that commercially available ice cream and cryogenically frozen ice cream are the most acceptable ones while the ice cream prepared from the LN2 infusion method is the least acceptable as compared to the other two.

Declarations of Interest

The author(s) declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Shrivastav A, Goswami TK (2018) Conventional Industrial Ice Cream Freezers and its thermal design: A review. J Food Sci Nutr 1(1): 21-28.
2. Das H (2005) Sensory evaluation using fuzzy logic. In Food processing operations analysis. Asian Books, New Delhi, pp. 383-402.
3. Perrot N, Ioannou I, Allais I, Curt C, Hossenlopp J, et al. (2006) Fuzzy concepts applied to food product quality control: A review. Fuzzy Sets Syst 157(9): 1145-1154.
4. Martinez L (2007) Sensory evaluation based on linguistic decision analysis. International Journal of Approximate Reasoning 44(2): 148-164.
5. Vivek K, Subbarao KV, Routray W, Kamini NR, Dash KK (2019) Application of fuzzy logic in sensory evaluation of food products: A comprehensive study. Food and Bioprocess Technology 13(1): 1-29.
6. ASTM Committee E-18 (1981) Guidelines for the Selection and Training of Sensory Panel Members. STP 758. Philadelphia, PA: American Society for Testing and Materials.
7. ASTM MNL-26. Sensory Testing Methods (2nd edn); Pennsylvania: American
8. Routray W, Mishra H (2012) Sensory evaluation of different drinks formulated from dahi (indian yogurt) powder using fuzzy logic. Journal of Food Processing and Preservation 36(1): 1-10.
9. Chen SM (1988) A new approach to handling fuzzy decision making. IEEE Transactions on Systems, Man and Cybernetics, 18(6): 1012-1016.
10. Bahram-Parvar M, Salehi F, Razavi S MA (2017) Adaptive neuro-fuzzy inference system (ANFIS) simulation for predicting overall acceptability of Ice Cream. Engineering in Agriculture, Environment and Food 10(2): 79-86.
11. Hameed N, Munawar S, Saeed S (2016) Predicting the quality of ice cream using neuro-fuzzy. In S. Khan, Science international (Lahore) ISSN 1013-5316 (Vol. 28).

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