Fuzzy Analysis of Sensory Data for Ranking of Beetroot Candy

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***Abstract*—Beetroot (*Beta vulgaris*) has long been recognized for its medicinal properties. In all over the world beetroot is easily available at low price still its processing into different value added products has almost been found negligible. In this study, efforts were made to develop a nutritious, salubrious and tasty beetroot candy, using ingredients like sugar, pectin and citric acid in different proportions. Initially, eight candy samples (S1, S2, S3, S4, S5, S6, S7 and S8) with different ratios of sugar, pectin and citric acid, respectively (60:2:0.25; 60:2:0.50; 60:3:0.25; 60:3:0.50; 65:2:0.25; 65:2:0.50; 65:3:0.25; 65:3:0.50), were screened by preliminary sensory analysis. Then out of these eight samples quality ranking was done using fuzzy logic model on the basis of its sensorial characteristics. Thus, the study concluded by allotting a quality rank based on the value of judgement membership function (Xf) of each beetroot candy sample: S8>S7>S6>S2>S5>S1>S3>S4.**

***Index Terms*—beetroot, candy, pectin, fuzzy logic**

I. Introduction

The trend of consumers getting more conscious towards their health and balance for nutrition in their diets has enabled them to seek for antioxidant rich foods with natural and organic sources of nutrients. Their preference for natural food supplements has been found to be increasing as compared to synthetic food supplements. Beetroot (*Beta vulgaris*) is considered as a "boon" for good health since the ancient times. [1] Beetroot juice contains a high level of biologically accessible antioxidants as well as many other health promoting compounds such as potassium, magnesium, folic acid, iron, zinc, calcium, phosphorus, sodium, niacin, biotin, B6 and soluble fibre. The colouring pigments of beetroot: betacyanin and betaxanthin, are responsible to impart purple and yellow colour respectively, which is collectively known as betalains. [2] These betalains have the antioxidant capabilities in beetroot. [3] Highest nitrate contents (>250mg/100g fresh weight) have also been reported for few vegetables including beetroot. [4] Beetroot being a very rich source of dietary NO3- has shown its potential in the reduction of blood pressure in human. [5], [6] Moreover beetroot has shown the presence of abundant of polyphenolic compounds. Though beetroot is easily available at low cost in the local market but it is not liked by the consumers in raw form because of its peculiar after taste. Hence this restricts its consumption, thus limiting the scope of the benefits it can provide. Therefore, a need of processed beetroot product was greatly felt and its processing in the form of a candy was thought to be an effective way to include beetroot in the diets of humans of all age groups.

Sensory Shelf Life (SSL) is defined as "the time period during which the product's sensory characteristics and performance are as intended by the manufacturer. [7] The product is consumable or usable during this period, providing the end user with the intended sensory characteristics, performance and benefits. Sensory evaluation is a form of subjective test, and fuzzy logic tool has been reported to remove this subjectivity in analyzing linguistic judgement. [8] Based on the panellist's preferences, ranking of the food products, is another added advantage of using fuzzy logic model. [8], [9] This tool has been extensively used for quality ranking on the basis of sensory evaluation of fried potato wedges. [9] Aromatic foods packed in developed starch based films, [10] drinks formulated from *dahi* (Indian yoghurt), [11] mango drinks and [12] various other food product development and comparison.

In the present study an effort has been made to develop a fuzzy comprehensive model for eight samples of beetroot candy, with different combinations, based on its prediction of sensory quality. This model is developed on the basis of sensory score given by a panel of especially trained judges to the candy sample with different quantity combinations of sugar, pectin and citric acid. This study demonstrates the usefulness of the developed fuzzy model in optimization and ranking of the candy with different ingredient ratios.

II. Materials and Methods

A. Preparation of Beetroot Candy

Fresh beetroot and sugar was procured from the local market of Varanasi. Food grade pectin and citric acid were also purchased from the local distributors. Utensils made up of stainless steel were used in the preparation of

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beet root candy. Potable water was available at the processing lab and the glass jars were used for the packaging and storage of the candy. Eight formulations of beetroot candy were prepared with 60 to 65 part sugar, 2 to 3 parts pectin and 025 to 0.5 parts citric acid for every 100 parts of beetroot pulp. The formulations were coded as S1, S2, S3, S4, S5, S6, S7 and S8 (Table I).

TABLE I. DIFFERENT FORMULATIONS OF BEETROOT CANDY

Sample	Ingredients % for 1kg beetroot pulp		
	Sugar	Pectin	Citric acid
S1	60	2	0.25
S2	60	2	0.50
S3	60	3	0.25
S4	60	3	0.50
S5	65	2	0.25
S6	65	2	0.50
S7	65	3	0.25
S8	65	3	0.50

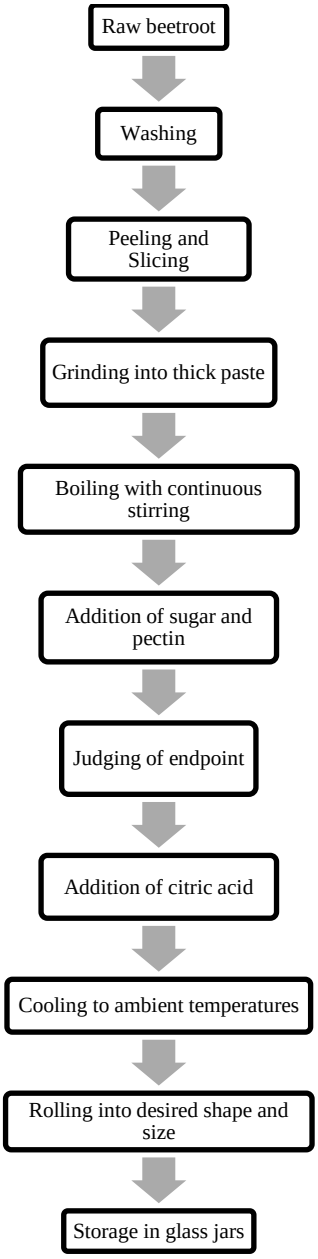

Figure 1. Flow chart for preparation of beetroot candy

Fresh beetroot were washed thoroughly then peeled and cut in to small pieces. The pieces were grinded in a grinder to make a fine paste out of it. The paste was first heated to boil with sugar (65%) and pectin (3%) was added to the boiling paste and was continuously stirred. The paste was then heat desiccated for 55 minutes with continuous stirring and at the end point of desired consistency citric acid was added @ 0.5%. Finally it was allowed to cool to ambient temperature and the thick paste was rolled into candies of desired shape and size. The flowchart for the preparation of candy is given (Fig. 1).

The composition of beetroot candy was 21.82% moisture, 69.4% carbohydrate, 1.92% protein, 0.74% fat and 6.12% fibre.

B. Sensory Evaluation

Fifteen judges were selected from the staff members and students of the Centre of Food Science and Technology, Banaras Hindu University, Varanasi, in the age group from 25-45 years, comprising 10 females and 5 males. They were trained to evaluate the overall appearance, mouthfeel, sweetness and taste of the given eight candy samples. [13] The judges were asked to rate the candy samples for these sensory attributes the samples were labelled as S-1, S-2, S-3, S-4, S-5, S-6, S-7 and S-8, respectively and the order of presentation of these samples were randomized. The score card for the sensory evaluation of the candy samples comprised five point sensory scale factors: Not satisfactory (NS), Fair (F), Medium (M), Good (G), and Excellent (EX). Each of the judges was given an individual score card and asked to give tick (√) mark to appropriate scale factor for all the quality attributes of samples after evaluation. Based on judges' individual perception regarding the beetroot candy, they were asked to give weightage for each of the quality attributes out of 100. [11] An average of these weightage was then determined for further analysis finally the results were analyzed using Fuzzy comprehensive model to find out the best and highly acceptable combination of the ingredients in the presented eight beetroot candy samples and the ranking was done accordingly.

C. Fuzzy Comprehensive Model for Sensory Scores

The fuzzy comprehensive model was used for the analysis of sensory data. Fuzzy model for the present problem was having three sets: (i) Factor set Uf, (ii) Evaluation set Vf and (iii) Fuzzy transformation Tf. The factor set, Uf includes all of the quality attributes such as hardness, taste, smell and mouth feel of the products. The evaluation set, Vf includes the scale factor for each of the quality attributes, such as Excellent, Good, Medium, Fair and Not satisfactory. For the fuzzy transformation (Tf) of the factor set (Uf) into evaluation set (Vf), numerical values assigned to the scale factors were: Excellent (EX) = 1, Good (GD) = 0.9, Medium (MD) = 0.7, Fair (FR) = 0.4 and Not satisfactory (NS) = 0.1.

[11] For the analysis, following evaluations were carried out:

Fuzzy membership function: It was calculated by adding the individual scale factor given to each of the quality attribute of the product and dividing it by the number of judges who tasted the product.

Normalized Fuzzy membership function: This was calculated by multiplying each of the above membership function with the assigned numerical value of the respective 'scale factor'.

Normalized Fuzzy membership function matrix: The elements of this matrix were formed by addition of the normalized fuzzy membership function of individual scales factor of respective quality attributes for each of the products given for sensory evaluation.

Judgment membership function matrix, X_f: The column values of a sample were then added and the individual values of the same column were divided by the "Maximum" of the added value. These values formed the elements of the judgment membership function matrix. Thus, the matrix decided the rank of the candy samples.

Judgment subset, Y_f: The average of numerical weightage (as fraction) given by the judges for individual quality attributes: 'overall apperarance', 'mouthfeel', 'sweetness' and 'taste' formed the judgement subset, Y_f:

$$Y_f = \begin{bmatrix} \frac{0.300}{OA} \\ \frac{0.200}{M} \\ \frac{0.200}{S} \\ \frac{0.300}{T} \end{bmatrix}$$

where:

OA= Overall appearance with weightage 0.300.

M= Mouthfeel with weightage 0.200

S= Sweetness with weightage 0.200

T= Taste with weightage 0.300

Quality-ranking subset, Z_f: Finally a comparison was made between the individual elements of the judgment membership function matrix (X_f) and the respective elements of the judgment subset (Y_f). Thus, the minimum of them was taken to form the quality-ranking subset, Z_f.

Ranking of the sample: Rank one was assigned to the sample, which had the maximum value in the quality-ranking subset Z_f. Likewise, all the eight candy samples were assigned a rank based on its overall acceptability.

III. Results and Discussion

Quality ranking on the basis of sensory attributes of beetroot candy: In the present study, sensory evaluation of a candy has played a very crucial role in optimization of its ingredients Eight samples of beetroot candy were finalized on the basis of the literature and setting up of jelly-like candy. [11] Sensory scores to the different ratios of the ingredients of beetroot candy were given by the assessors according to the sensory chart. The table shows the result of the 'Fuzzy Logic Analysis'. The scale factors: Excellent (EX), Good (GD), Medium (MD), Fair (FR) and Not satisfactory (NS) are assigned to the quality factors: overall appearance, mouth feel, sweetness and taste for all the samples of candy. Fuzzy membership Function (FMF) and Normalized Fuzzy Membership Function (NFMF) were then calculated and presented in the same (Table II & Table III). The total of all the NFMF of the samples was then used to determine the 'Judgment Membership Function' (JMF). The JMF values for all the eight samples are given in Table IV. These values of JMF were then compared with the average of weightage given by the panelist for each of the quality attributes. Based on this, the quality ranking sub set values were calculated (Table V). Comparing the weightage average of quality attributes and the JMF formed, the minimum of these two was assigned as the quality ranking subset value. The ranks of the samples were assigned from the maximum of quality ranking subset value of the sample. Based on this value the overall ranking to the candy samples were given, which is as follows: S8>S7>S6>S2>S5>S1>S3>S4.

TABLE II. Scale Factor, Fuzzy Membership Function (FMF) and Normalized Membership Function (NFMF) for Quality Attributes of First Four Samples of Beetroot Candy

Sensory attribute	Scale factor	S-1	S-1:FMF	S-1:NFMF	S-2	S-2:FMF	S-2:NFMF	S-3	S-3:FMF	S-3:NFMF	S-4	S-4:FMF	S-4:NFMF
	EX	5	0.3333	0.3330	5	0.3333	0.3330	3	0.2000	0.2000	2	0.1333	0.1330
	GD	4	0.2667	0.2400	5	0.3333	0.3000	5	0.3333	0.3000	6	0.4000	0.3600
Overall Appearance	MD	4	0.2667	0.1867	1	0.0667	0.0467	5	0.3333	0.2333	5	0.3333	0.2333
	FR	2	0.1333	0.0533	4	0.2667	0.1067	2	0.1333	0.0533	2	0.1333	0.0533
	NS	0	0	0	0	0	0	0	0	0	0	0	0
	Total	15		**0.8130**	15		**0.7864**	15		**0.7866**	15		**0.7796**
	EX	2	0.1333	0.1330	0	0	0	4	0.2667	0.2670	1	0.0667	0.0670
	GD	7	0.4667	0.4200	8	0.5333	0.4800	5	0.3333	0.3000	8	0.5333	0.4800
Mouth feel	MD	4	0.2667	0.1867	4	0.2667	0.1867	6	0.4000	0.2800	5	0.3333	0.2333
	FR	1	0.0667	0.0267	2	0.1333	0.0533	0	0	0	1	0.0667	0.0267
	NS	1	0.0667	0.0067	1	0.0667	0.0067	0	0	0	0	0	0
	Total	15		**0.7731**	15		**0.7267**	15		**0.8470**	15		**0.8070**
	EX	1	0.0667	0.0670	6	0.4000	0.4000	5	0.3333	0.3330	5	0.3333	0.3330
	GD	10	0.6667	0.6000	5	0.3333	0.3000	4	0.2667	0.2400	4	0.2667	0.2400
Sweetness	MD	2	0.1333	0.0933	2	0.1333	0.0933	6	0.4000	0.2800	5	0.3333	0.2333
	FR	1	0.0667	0.0267	2	0.1333	0.0532	0	0	0	1	0.0667	0.0267
	NS	1	0.0667	0.0067	0	0	0	0	0	0	0	0	0
	Total	15		**0.7937**	15		**0.8465**	15		**0.8530**	15		**0.8330**

	EX	0	0	0	6	0.4000	0.4000	2	0.1333	0.1330	2	0.1333	0.1330
	GD	7	0.4667	0.4200	5	0.3333	0.3000	3	0.2000	0.1800	6	0.4000	0.3600
Taste	MD	3	0.2000	0.1400	3	0.2000	0.1400	6	0.4000	0.2800	6	0.4000	0.2800
	FR	4	0.2667	0.1067	1	0.0667	0.0267	3	0.2000	0.0800	0	0	0
	NS	1	0.0667	0.0067	0	0	0	1	0.0667	0.0067	1	0.0667	0.0067
	Total	15		**0.6734**	15		**0.8667**	15		**0.6797**	15		**0.7797**
	Total		S1t =	**3.0532**		S2t =	**3.2263**		S3t =	**3.1663**		S4t =	**3.1993**

TABLE III. SCALE FACTOR, FUZZY MEMBERSHIP FUNCTION (FMF) AND NORMALIZED MEMBERSHIP FUNCTION (NFMF) FOR QUALITY ATTRIBUTES OF LAST FOUR SAMPLES OF BEETROOT CANDY

Sensory attribute	**Scale factor**	**S-5**	**S-5:FMF**	**S-5:NFMF**	**S-6**	**S-6:FMF**	**S-6:NFMF**	**S-7**	**S-7:FMF**	**S-7:NFMF**	**S-8**	**S-8:FMF**	**S-8:NFMF**
	EX	5	0.3333	0.3330	6	0.4000	0.4000	8	0.5333	0.5330	10	0.6667	0.6670
	GD	5	0.3333	0.3000	5	0.3333	0.3000	2	0.1333	0.1200	3	0.2000	0.1800
Overall Appearance	MD	4	0.2667	0.1867	2	0.1333	0.0933	3	0.2000	0.1400	1	0.0667	0.0467
	FR	1	0.0667	0.0267	0	0	0	2	0.1333	0.0533	1	0.0667	0.0267
	NS	0	0	0	2	0.1333	0.0133	0	0	0	0	0	0
	Total	15		**0.8464**	15		**0.8066**	15		**0.8463**	15		**0.9204**
	EX	2	0.1333	0.1330	8	0.5333	0.5333	8	0.5333	0.5330	9	0.6000	0.6000
	GD	7	0.4667	0.4200	1	0.0667	0.0600	3	0.2000	0.1800	3	0.2000	0.1800
Mouth feel	MD	1	0.0667	0.0467	5	0.3333	0.2333	3	0.2000	0.1400	2	0.1333	0.0933
	FR	4	0.2667	0.1067	1	0.0667	0.0267	1	0.0667	0.0267	1	0.0667	0.0267
	NS	1	0.0667	0.0067	0	0	0	0	0	0	0	0	0
	Total	15		**0.7131**	15		**0.8533**	15		**0.8797**	15		**0.9000**
	EX	1	0.0667	0.0670	7	0.4667	0.4670	7	0.4667	0.4670	12	0.8000	0.8000
	GD	6	0.4000	0.3600	4	0.2667	0.2400	4	0.2667	0.2400	1	0.0667	0.0600
Sweetness	MD	5	0.3333	0.2331	3	0.2000	0.1400	4	0.2667	0.1867	2	0.1333	0.0933
	FR	1	0.0667	0.0268	1	0.0667	0.0267	0	0	0	0	0	0
	NS	2	0.1333	0.0013	0	0	0	0	0	0	0	0	0
	Total	15		**0.6882**	15		**0.8737**	15		**0.8937**	15		**0.9533**
	EX	4	0.2667	0.2670	8	0.5333	0.5330	8	0.5333	0.5330	10	0.6667	0.6670
	GD	5	0.3333	0.3000	5	0.3333	0.3000	5	0.3333	0.3000	4	0.2667	0.2400
Taste	MD	5	0.3333	0.2333	1	0.0667	0.0467	1	0.0667	0.0467	1	0.0667	0.0467
	FR	0	0	0	0	0	0	1	0.0667	0.0267	0	0	0
	NS	1	0.0667	0.0067	1	0.0667	0.0067	0	0	0	0	0	0
	Total	15		**0.8070**	15		**0.8864**	15		**0.9064**	15		**0.9537**
	Total	S5t= 3.0547			S6t=3.4200			S7t=3.5261			S8t=3.7274		

TABLE IV. JUDGMENT MEMBERSHIP FUNCTIONS (JMF) OF ALL EIGHT SAMPLES OF BEETROOT CANDY

Sensory Parameters	**JMF**							
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
Overall Appearance	0.2181	0.2110	0.2110	0.2092	0.2271	0.2164	0.2270	0.2469
Mouthfeel	0.2074	0.1949	0.2272	0.2165	0.1913	0.2289	0.2360	0.2415
Sweetness	0.2129	0.2271	0.2288	0.2235	0.1846	0.2344	0.2398	0.2558
Taste	0.1807	0.2325	0.1824	0.2092	0.2165	0.2378	0.2432	0.2559

TABLE V. QUALITY RANKING (QR) OF ALL EIGHT SAMPLES OF BEETROOT CANDY

Sensory Parameters	**Weightage Average**	**S1:QR**	**S2:QR**	**S3:QR**	**S4:QR**	**S5:QR**	**S6:QR**	**S7:QR**	**S8:QR**
Overall Appearance	0.300	0.218	0.211	0.211	0.209	0.227	0.216	0.227	0.246
Mouthfeel	0.200	0.200	0.195	0.200	0.200	0.191	0.200	0.200	0.200
Sweetness	0.200	0.200	0.200	0.200	0.200	0.185	0.200	0.200	0.200
Taste	0.300	0.180	0.232	0.182	0.209	0.216	0.237	0.243	0.255
		0.218	**0.232**	**0.211**	**0.209**	**0.227**	**0.237**	**0.243**	**0.255**
Ranking		**VI**	**IV**	**VII**	**VIII**	**V**	**III**	**II**	**I**

IV. CONCLUSION

In nutshell, the present study clearly demonstrates that the beetroot candy prepared using 65% sugar, 3% pectin and 0.5% citric acid was highly acceptable in terms of sensorial characteristics like overall appearance, mouthfeel, taste and sweetness. Thus, sample number S8 scored the highest value of judgement membership function (X_f), followed by S7, S6, S2, S5, S1, S3 and S4. All possible combinations of all three ingredients, *viz.* sugar, citric acid and pectin, were analysed. The results revealed that as the concentration of sugar in was increased beyond 65% lead to crystallization defect in candy and as the level of pectin was increased beyond 3% the texture was found to be hard along with an unsatisfactory aftertaste. However, citric acid was mainly added to impart a tangy flavour to the candy but it was found that citric acid @ 0.5% was most suitable to set the sugar-pectin-acid equilibrium, which is very important to set a jelly like candy. The beetroot candy is a healthy

substitute of the artificial flavoured candy available in the local market. Finally it was concluded that there is an enormous scope of processed beetroot products and this study would prove to be a pathway for the further development of processed beetroot products.

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