International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM November 2023, 14(11):1487-1494 Print ISSN 0976-3988 Online ISSN 0976-4038 **Article** AR4867a

Research Article *Natural Resource Management*

DOI: HTTPS://DOI.ORG/10.23910/1.2023.4867a

Fuzzy Logic for Sensory Evaluation of Paper Sweet (*Pootharekulu*)

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ABSTRACT

The present study was conducted at Atreypuramu, East Godavari district, Andhra Pradesh, India during June-August, 2022 with the preparation of paper sweet variants followed by fuzzy logic sensory analysis. Initially, polished/milled *Jaya* variety rice soaked, ground with water and made into batter. The batter without any coarse particles diluted in separate flat containers. Then, a thin cotton cloth was dipped in the diluted batter and spread over the hot curved surface of inverted pot almost maintained at 120–135°C. This structures the paper-thin external front of the sweet. The size of produced rice starch edible film was about 41×30 cm^2 and thickness in the range of 0.02–0.05 cm. The four paper sweet variants were prepared by rolling the rice starch film stuffed with various fillings including jaggery/sugar and nuts & jaggery/sugar alone. Fuzzy logic sensory study was conducted for analysis of paper sweets and to compare the acceptability of these paper sweet variants. Ranking was assigned to each sample by calculating fuzzy membership unction, normalized fuzzy membership function, normalized fuzzy membership function matrix, judgment membership function matrix, judgment subset and quality ranking subset. Finally, the weightage average was compared with quality ranking of all paper sweet variants. The results concluded that all four samples were quite comparable; however, paper sweet with jaggery and nuts received the best response.

KEYWORDS: Fuzzy logic, paper sweet, *pootharekulu*, sensory evaluation, traditional

***Citation* (VANCOUVER):** Sivamma and Jagannadha, Fuzzy Logic for Sensory Evaluation of Paper Sweet (*Pootharekulu*). *International Journal of Bio-resource and Stress Management*, 2023; 14(11), 1487-1494. HTTPS://DOI.ORG/10.23910/1.2023.4867a.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Funding: The research was conducted with the support from Institute.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 28th August 2023 RECEIVED in revised form on 24th October 2023 ACCEPTED in final form on 01st November 2023 PUBLISHED on 18th November 2023

1. INTRODUCTION

Paper sweet also known as *Pootharekulu* is a unique, fascinate and popular traditional Indian sweet of Andhra Pradesh and Telangana states. In Telugu *Pootha* means coating and *reku* translates to sheet. Paper sweet has got the magic of unique flavour and richness. The paper sweet has acquired its own specialty in nutrition, health benefits and creation of economy to the economically weaker families as a cottage industry. The paper sweet is a wafer-thin rice starch layer resembling like paper and is stuffed with sugar/jaggery powder, clarified butter and chunks of dry fruits and/or nuts.

There are mainly 4 variants of paper sweets are available in the market i.e., paper sweet stuffed with (a) jaggery and nuts, (b) sugar and nuts, (c) jaggery alone and (d) sugar alone. The processors of paper sweet make all the above said variants without having awareness on the type of variant most accepting by the consumers. Eventually, the product stock which is not mostly preferred by the consumers may remain at the processor level and low-income generation for the variant. In this article an attempt is made to bring in its preparation process and sensory quality of different paper sweet variants by conducting sensory evaluation. The present study, a fuzzy logic approach to analyze the sensory data of different paper sweet variants has been exploited to increase the accuracy of sensory quality evaluation and acceptability at both market and consumer level.

Sensory evaluation is an experimental technique to induce, measure, evaluate and construe the sensory responses for a food product, which are generally perceived by sight, smell, touch, taste and hearing (Stone et al., 2012). It is used at several stages of new product development and for comparison of similar type of products (Debjani et al., 2013). This evaluation technique provides the food processing industries and food scientists with useful and important information on the sensory quality of foo, to estimate the overall acceptability of a product by consumers (Beriain et al., 2000, Davidson and Sun, 1998).

Sensory analysis with subjective method has great variability and therefore, requires a robust method of sensory evaluation. Moreover, subjective method of sensory analysis carries vagueness and ambiguity among judges and is quite uncertain. Fuzzy logic is an important tool by which indistinct and vague data can be analyzed and important conclusions regarding acceptance, rejection, ranking, strong and weak attributes of food can be drawn. In fuzzy modelling, linguistic variables (not satisfactory, good, medium, fair and excellent) are used for developing relationship between independent (taste, colour and appearance, flavour, texture and overall acceptance) and dependent (acceptance, rejection, ranking, strong and weak attributes of food) variables (Das, 2005, Routray and Mishra, 2011).

In fuzzy logic sensory analysis, the data is mathematically interpreted and analyzed as membership functions which are a representation of the non-numerical sensory observations of the panel members (Sugumar and Guha, 2022). Fuzzy sets can be used for analysis of sensory data instead of average scores to compare the samples attributes. Fuzzy sets are not confined to deterministic value and have a merit in sensory evaluation because human expressions on filling for foods are fuzzy rather than deterministic. The developed fuzzy mathematical models perform remarkably well in the evaluation and ranking of food products (Fatma et al., 2016). Fuzzy sets provide the mathematical methods that can represent the uncertainty of human's expressions attributes of ready to eat (RTE) food that are evaluated by human senses are colour and appearance texture, flavour, taste and overall acceptance. The fuzzy model can be used to determine the importance of individual factors to the overall quality of product.

2. MATERIALS AND METHODS

2.1. Preparation of paper sweet

Preparation of paper sweets was carried out at Atreypuramu, East Godavari district, Andhra Pradesh, India in the month of June, 2022. It is situated on the latitude of 16°49'60"north and longitude of 81°47'30" east. Mainly three steps involved in the preparation of paper sweet: 1) preparation of batter, 2) preparation of rice starch film and 3) rolling of film with stiffing

2.1.1. Preparation of batter

Polished/milled rice soaked for two to three hours, ground with water for almost one to two hours and made into batter. The batter must not contain coarse particles. Batter was then diluted in separate flat containers.

2.1.2. Preparation of rice starch based edible film

Rice based batter was diluted in separate flat containers and then a thin cotton cloth was dipped in the diluted batter and spread over the hot curved surface of inverted pot almost maintained at 120–135°C (Figure 1). It was removed in a jiffy leaving a dainty film of the starch on the pot (Figure 2). This structures the paper-thin external front of the sweet. The size of produced rice starch edible film was about 41×30 cm^2 and thickness in the range of 0.02–0.05 cm.

2.1.3. Rolling of film with stuffing

Edible film was coated with clarified butter and wrapped itself expertly along with jaggery powder and nuts or sugar powder and nuts or jaggery powder alone or sugar powder alone (Figure 3 and 4). A gentle application of clarified butter softens the paper to allow folding in the fillings.

2.2. Sensory evaluation

The samples were named and coded as paper sweet with jaggery powder and nuts (S_1), paper sweet with sugar powder and nuts (S_2), Paper sweet with jaggery alone (S_3) and paper sweet with sugar alone(S_4). Twenty-five semi-trained panelists were selected included faculty and post graduate students from the Regional Agricultural Research Station, Acharya N. G. Ranga Agricultural University, Anakapalle, Andhra Pradesh, India in the age group between 22 and 55 years included 13 female and 12 males. The quality attributes selected for the organoleptic properties of paper sweet were appearance, colour, taste, flavour, crispiness, mouthfeel and overall quality.

Figure 1: Spreading the batter over hot pot with cloth

Figure 2: Removal of thin edible films from earthen pot

Figure 3: Rolling of rice paper with clarified butter, jaggery/ sugar powder and nuts

Figure 4: Paper sweet stuffed with (a) jaggery powder and nuts, (b) sugar powder and nuts; (c) jaggery alone and (d) sugar alone

Judges were acquainted with the appearance, colour, taste, flavour, crispiness, mouthfeel, and overall quality of paper sweet sample before the actual sensory evaluation. All four paper sweet samples were subjected to sensory evaluation to a panel of twenty-five judges and not more than two samples were presented at a time. They were also advised to wash off their mouth with water after sensory analysis of each sample. Judges were asked to score the paper sweet samples on a 5-point hedonic scale. Judges were instructed to give tick mark in the respective fuzzy scale factor for each of the quality attribute of the sample after evaluation (Jaya and Das 2003). The sensory scale was divided into 5 linguistic scale responses that range from not satisfactory, fair, medium, good and excellent. Similar scales were also established for the sensory attributes, which range from 1=not at all important, 2=somewhat important, 3=important, 4=highly important and 5=extremely important. After evaluating the sample, judges were asked to give marks for each quality attributes based on their own taste regarding paper sweet. These marks were called as weightage of each of the attributes. Average of weightages of each attribute given

by all the judges were found and called average weightage of that quality attribute. The results were analyzed by using fuzzy comprehensive model to find out the best of fourpaper sweet variants.

2.2.1. Fuzzy comprehensive model for sensory scores

Fuzzy model for the present problem was having three sets: (i) Factor set U_f, (ii) Evaluation set $V_f$and (iii) Fuzzy transformation T_f. The factor set, U_f contains all of the quality attributes such as appearance, colour, taste, flavour, crispiness, mouthfeel and overall quality of the products. The evaluation set, V_f includes the scale actor for each of the quality attributes, such as Excellent, Good, Medium, Fair and Not satisfactory. For the fuzzy transformation (T_f) of the factor set (U_f) into evaluation set (V_f), numerical values assigned to the scale factors were (EX) = 1, Good (GD) = 0.9, Medium (MD) = 0.7, Fair (FR) = 0.4 and Not satisfactory (NS) = 0.1.

2.2.2. Evaluation of analysis

2.2.2.1. Fuzzy membership function (FMF), M_f

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 evaluated the product (Jaya and Das, 2003).

$M_f = \sum V_f$/total of judges ……(1)

2.2.2.2. Normalized fuzzy membership function (NFMF), N_f

NFMF was calculated by multiplying each of the fuzzy membership function with the assigned numerical value of the respective 'scale factor'.

$N_f=M_f \times S_f$ ……(2)

2.2.2.3. Normalized fuzzy membership function matrix, O_f

Addition of the normalized fuzzy membership function of individual linguistic term of respective quality attributes for each of the product given for sensory evaluation formed the elements of the normalized fuzzy membership function matrix. All the element of the normalized matrix were calculated and written in the form of a matrix called normalized fuzzy membership function matrix having its row as quality attributes and the column as samples number.

$O_f = \sum N_f$ for each quality attribute ……(3)

2.2.2.4. 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 paper sweet.

$X_f=O_f/\max \sum O_f$ ……..(4)

2.2.2.5. Judgment subset, Y_f

The average of numerical weightage given by the judges for individual quality attributes: appearance, colour, taste, flavour, crispiness, mouthfeel, overall quality formed the judgement subset as judgement membership function explained in the above steps.

2.2.2.6. Quality-ranking subset, Z_f

Finally, 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.

2.2.2.7. Ranking of the sample

Highest rank (I) was assigned to the sample which had the maximum value in the quality ranking subset Z_f. Then the quality attribute, which gave the highest value, was considered as the reason for that sample to get the highest rank.

Calculations for determination of different membership functions

• Fuzzy membership function (FMF), M_f=(Individual scores of samples/total no.of judges)

Eg: FMF for sample S_1 (Appearance)=11/25=0.44

=10/25=0.4

• Normalized fuzzy membership function (NFMF), N_f = FMF×Scale factor

Eg: NFMF for sample S_1(Appearance)=0.44×1=0.44

=0.4×0.9=0.36

• Normalized fuzzy membership function matrix, O_f

O_f=Total of NFMF (Appearance + Colour+Taste+Flavour +Crispiness+Mouthfeel+Overall quality)

Eg: sample S_1 (O_{f1})=0.876+0.912+0.86+0.856+0.792+0.8 88+0.904=6.08

Sample S_2 (O_{f2})=0.764+0.784+0.74+0.748+0.668+0.768+0 .776+5.248 = 5.248

Repeated the same procedure for all samples and sensory attributes

• From above step, find the maximum of the total of normalized fuzzy membership function.

e.g.: sample S_1(O_{f1}=6.08)

Judgment membership function (JMF), X_f=(total of NFMF)/(maximum o total NFMF)

Eg: X_f for sample S_1-Appearance=0.876/6.08=0.144

Colour=0.912/6.08=0.15

Repeat the same procedure for all samples and sensory attributes. The values of the JMF, were then compared with the average weightage given by the judges for each of the quality attributes. Based on this, the quality ranking sub set values were calculated.

• Quality ranking subset (QR): Comparing the weightage average of quality attributes and the judgment membership function formed, the minimum of these was assigned as the quality ranking subset value.

3. RESULTS AND DISCUSSION

3.1. Quality ranking on the basis of sensory attributes of paper sweet

The obtained data was analysed using a fuzzy decision-makingapproach to determine the ranking of the paper sweet samples. Fuzzy Membership Function (M_f) and Normalized Fuzzy Membership Function (N_f) were calculated using the equations (1) and (2).

3.2. Ranking of paper sweet

The sensory data results of paper sweets are presented in Table 1. Various sensory attributes of normalised fuzzy membership function for appearance, colour, taste, flavour, crispiness, mouthfeel and overall quality of all paper sweet samples were 0.876(S_1), 0.764(S_2), 0.704(S_3) and 0.612(S_4); 0.912(S_1), 0.784(S_2), 0.74(S_3) and 0.64(S_4); 0.876(S_1), 0.764(S_2), 0.704(S_3) and 0.612(S_4); 0.86(S_1), 0.74(S_2), 0.728(S_3) and 0.636(S_4); 0.856(S_1), 0.748(S_2), 0.788(S_3) and 0.8(S_4); 0.792(S_1), 0.668(S_2), 0.652(S_3) and 0.608(S_4); 0.88(S_1), 0.768(S_2), 0.768(S_3) and 0.668(S_4); 0.904(S_1), 0.776(S_2), 0.788(S_3) and 0.612(S_4), respectively.

Table 1: Scale factor, fuzzy membership function (FMF) and normalized membership function (NFMF) for quality attributes of paper sweets

Quality attribute	SQF	Scale factor	Paper sweet with jaggery + nuts			Paper sweet with sugar + nuts			Paper sweet with jaggery			Paper sweet with sugar		
			NJR	FMF (Mf)	NFMF (Nf)	NJR	FMF (Mf)	NFMF (Nf)	NJR	FMF (Mf)	NFMF (Nf)	NJR	FMF (Mf)	NFMF (Nf)
Appearance	EX	1	11	0.440	0.440	8	0.320	0.320	4	0.160	0.160	2	0.080	0.080
	GD	0.9	10	0.400	0.360	5	0.200	0.180	5	0.200	0.180	4	0.160	0.144
	MD	0.7	2	0.080	0.056	9	0.360	0.252	9	0.360	0.252	11	0.440	0.308
	FR	0.4	1	0.040	0.016	0	0	0	7	0.280	0.112	4	0.160	0.064
	NS	0.1	1	0.040	0.004	3	0.120	0.012	0	0	0	4	0.160	0.016
Total			25		0.876	25		0.764	25		0.704	25		0.612
Colour	EX	1	13	0.520	0.520	10	0.400	0.400	2	0.080	0.080	2	0.080	0.080
	GD	0.9	10	0.400	0.360	6	0.240	0.216	8	0.32	0.288	9	0.360	0.324
	MD	0.7	1	0.040	0.028	5	0.200	0.140	12	0.480	0.336	5	0.200	0.140
	FR	0.4	0	0	0	1	0.040	0.016	2	0.080	0.032	5	0.200	0.080
	NS	0.1	1	0.040	0.004	3	0.120	0.012	1	0.040	0.004	4	0.160	0.016
Total			25		0.912	25		0.784	25		0.740	25		0.640
Taste	EX	1	11	0.440	0.440	5	0.200	0.200	5	0.200	0.200	2	0.080	0.080
	GD	0.9	8	0.320	0.288	8	0.320	0.288	11	0.440	0.396	7	0.280	0.252
	MD	0.7	4	0.160	0.112	6	0.240	0.168	1	0.040	0.028	8	0.320	0.224
	FR	0.4	1	0.040	0.016	5	0.200	0.080	6	0.240	0.096	4	0.160	0.064
	NS	0.1	1	0.040	0.004	1	0.040	0.004	2	0.080	0.008	4	0.160	0.016
Total			25	0	0.860	25		0.740	25		0.728	25		0.636
Flavour	EX	1	11	0.440	0.440	3	0.120	0.120	8	0.320	0.32	11	0.440	0.440
	GD	0.9	6	0.240	0.216	12	0.480	0.432	8	0.320	0.288	5	0.200	0.180
	0MD	0.7	6	0.240	0.168	6	0.240	0.168	5	0.200	0.140	5	0.200	0.140
	FR	0.4	2	0.080	0.032	1	0.040	0.016	2	0.080	0.032	2	0.080	0.032
	NS	0.1	0	0	0	3	0.120	0.012	2	0.080	0.008	2	0.080	0.008
Total			25		0.856	25		0.748	25		0.788	25		0.800

Table 1: Continue...

Quality attribute	SQF	Scale factor	Paper sweet with jaggery + nuts			Paper sweet with sugar + nuts			Paper sweet with jaggery			Paper sweet with sugar		
			NJR	FMF (Mf)	NFMF (Nf)	NJR	FMF (Mf)	NFMF (Nf)	NJR	FMF (Mf)	NFMF (Nf)	NJR	FMF (Mf)	NFMF (Nf)
Crispiness	EX	1	9	0.360	0.360	4	0.160	0.16	5	0.200	0.200	2	0.080	0.080
	GD	0.9	7	0.280	0.252	8	0.320	0.288	6	0.240	0.216	8	0.320	0.288
	MD	0.7	5	0.200	0.140	6	0.240	0.168	5	0.200	0.140	6	0.240	0.168
	FR	0.4	2	0.080	0.032	2	0.080	0.032	5	0.200	0.080	3	0.120	0.048
	NS	0.1	2	0.080	0.008	5	0.200	0.020	4	0.160	0.016	6	0.240	0.024
Total			25		0.792	25		0.668	25		0.652	25		0.608
Mouthfeel	EX	1	9	0.360	0.360	5	0.200	0.200	6	0.240	0.240	3	0.120	0.120
	GD	0.9	12	0.480	0.432	10	0.400	0.360	10	0.400	0.360	8	0.320	0.288
	MD	0.7	2	0.080	0.056	5	0.200	0.140	4	0.160	0.112	6	0.240	0.168
	FR	0.4	2	0.080	0.032	4	0.160	0.064	3	0.120	0.048	5	0.200	0.08
	NS	0.1	0	0	0	1	0.040	0.004	2	0.080	0.008	3	0.120	0.012
Total			25		0.880	25		0.768	25		0.768	25		0.668
Overall quality	EX	1	10	0.400	0.400	6	0.240	0.240	5	0.200	0.20	3	0.120	0.120
	GD	0.9	12	0.480	0.432	8	0.320	0.288	11	0.440	0.396	7	0.280	0.252
	MD	0.7	2	0.080	0.056	8	0.320	0.224	6	0.240	0.168	4	0.160	0.112
	FR	0.4	1	0.040	0.016	1	0.040	0.016	1	0.040	0.016	7	0.280	0.112
	NS	0.1	0	0	0	2	0.080	0.008	2	0.080	0.008	4	0.160	0.016
Total			25		0.904	25		0.776	25		0.788	25		0.612
Of					Of1 = 6.080			Of2 = 5.248			Of3 = 5.168			Of4 = 4.576

SQF: Sensory quality factor; NJR: No. of judges rated; EX: Excellent; GD: Good; MD: Medium; FR: Fair; NS: Not satisfactory; Of : Normalized fuzzy membership function matrix Of1,Of2, Of3 and Of4: Normalized fuzzy membership function matrix of paper sweet with jaggery and nuts, sugar and nuts, jaggery alone and sugar alone

The results indicated that the paper sweet with jaggery and nuts (S_1) had good sensory attributes compared with other paper sweet variants and highest acceptability at the consumer level. Jaggery has much higher nutritionalandmedicinalvalues like its anti-carcinogenic and antitoxic activity, the main reason behind the consumer preference of jaggery over sugar in this health-conscious era(Rao et al., 2007). S_1(paper sweet with jaggery and nuts) consisted of dry nuts (high calorie food) which are a great source of proteins, vitamins, minerals, dietary and fiber aided to improve the nutritional quality and also sensory qualities of paper sweet.

These two membership functions (M_f and N_f) led to calculation of Normalized Fuzzy Membership Function Matrix (O_f) using equation (3). The maximum and minimum of NFMF matrix (O_f) value were 6.08 and 4.576 obtained for S_1 and S_4, respectively. The matrix O_f was converted to Judgment Membership Function Matrix X_f by using eq. (4)and presented in Table 2. Paper sweet with jaggery and nuts (S_1) had the highest O_f value which was used for calculation of Judgement membership function (JMF).

The values of judgement membership function were then compared with the average of weightage given by the panellist for each of the quality attributes and the weightage average values for each of the quality attribute were calculated and presented in Table 3 and 4. The weightage average values for appearance, colour, taste, flavour, crispiness, mouthfeel and overall quality were 0.1329, 0.1357, 0.1615, 0.1448, 0.1266, 0.1434 and 0.1552, respectively (Table 5). The order of preference of quality attributes for paper sweet samples in general was as follows: taste >overall quality >flavour>mouthfeel >colour>appearance >crispiness. Comparing the weightage average of quality attributes and judgement membership function formed, it was found that

score of the sample S_1 (paper sweet with jaggery and nuts) was the highest (QR = 0.141) based on the score obtained for the quality attribute taste followed by S_2 (paper sweet with sugar and nuts), S_3 (paper sweet with jaggery alone) and S_4 (paper sweet with sugar alone) with QR value 0.122, 0.1197 and 0.105, respectively. Also, the quality responses i.e., appearance, colour, flavour, crispiness, mouthfeel and overall quality values of S_1 were higher than other paper sweet variants. It may be concluded that, paper sweet with jaggery and nuts had best quality and more acceptable at the consumer level.

Table 2: Evaluation of judgment membership functions (JMF) of paper sweet

Quality attribute	Judgment membership functions (JMF), Xf			
	Jaggery and nuts	Sugar and nuts	Jaggery alone	Sugar alone
Appearance	0.1441	0.1256	0.1157	0.1006
Colour	0.1500	0.1289	0.1217	0.1052
Taste	0.1414	0.1217	0.1197	0.1046
Flavour	0.1408	0.1230	0.1296	0.1315
Crispiness	0.1303	0.1098	0.1072	0.1000
Mouthfeel	0.1447	0.1263	0.1263	0.1098
Overall quality	0.1487	0.1276	0.1296	0.1006

Table 4: Evaluation of judgment membership functions (JMF) of paper sweet

Quality attribute	Sum of NFMF	JMF
Appearance	0.7600	0.1329
Colour	0.7760	0.1357
Taste	0.9240	0.1615
Flavour	0.8280	0.1448
Crispiness	0.7240	0.1266
Mouthfeel	0.8200	0.1434
Overall quality	0.8880	0.1552
Total	5.7200	

Table 3: fuzzy membership function (FMF) and normalized membership function (NFMF) of different quality attributes

Quality attribute	Scale factor	No. of judges rated	FMF	NFMF
Appearance	EIMP	4	0.160	0.160
	HIMP	9	0.360	0.324
	IMP	8	0.320	0.224
	SIMP	3	0.120	0.048
	NIMP	1	0.040	0.004
Total		25		0.760
Colour	EIMP	4	0.160	0.160
	HIMP	8	0.320	0.288
	IMP	11	0.440	0.308
	SIMP	1	0.040	0.016
	NIMP	1	0.040	0.004
Total		25		0.776
Taste	EIMP	13	0.520	0.520
	HIMP	10	0.400	0.360
	IMP	1	0.040	0.028
	SIMP	1	0.040	0.016
	NIMP	0	0	0
Total		25		0.924
Flavour	EIMP	7	0.280	0.280
	HIMP	10	0.400	0.360
	IMP	6	0.240	0.168
	SIMP	1	0.040	0.016
	NIMP	1	0.040	0.004
Total		25		0.828
Crispiness	EIMP	5	0.200	0.200
	HIMP	6	0.240	0.216
	IMP	9	0.360	0.252
	SIMP	3	0.120	0.048
	NIMP	2	0.080	0.008
Total		25		0.724
Mouthfeel	EIMP	9	0.360	0.360
	HIMP	6	0.240	0.216
	IMP	7	0.280	0.196
	SIMP	3	0.120	0.048
	NIMP	0	0	0
Total		25		0.820
Overall quality	EIMP	8	0.320	0.320
	HIMP	13	0.520	0.468
	IMP	3	0.120	0.084
	SIMP	1	0.040	0.016
	NIMP	0	0	0
Total		25		0.888

Table 5: Evaluation of quality ranking (QR) of paper sweet

Quality attribute	weightage average	S_1:QR	S_2:QR	S_3:QR	S_4:QR
Appear-ance	0.1329	0.1441	0.1256	0.1157	0.1006
Colour	0.1357	0.1500	0.1289	0.1217	0.1052
Taste	0.1615	0.1414	0.1217	0.1197	0.1046
Flavour	0.1448	0.1408	0.1230	0.1296	0.1315
Crispiness	0.1266	0.1303	0.1098	0.1072	0.1000
Mouthfeel	0.1434	0.1447	0.1263	0.1263	0.1098
Overall quality	0.1552	0.1487	0.1276	0.1296	0.1006
Total		1	0.8629	0.8498	0.7523
	Ranking	I	II	III	IV

4. CONCLUSION

The paper sweet sample prepared from jaggery and nuts was scored highest value of judgement membership function (X_f) followed by paper sweet prepared from sugar and nuts, jaggery alone and sugar alone. Both S_2(sugar and nuts) and S_3(jaggery alone) had almost similar quality attributes. Paper sweet with jaggery and nuts sample was highly acceptable in terms of sensory qualities like appearance, colour, taste, flavour, crispiness, mouthfeel and overall quality at the consumer level.

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