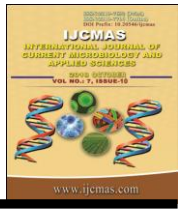
Int.J.Curr.Microbiol.App.Sci (2018) *7*(10): 551-562

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 10 (2018)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2018.710.061

Sensory Evaluation of Ready to Eat Snack Food Using Fuzzy Logic

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Keywords

Sensory evaluation, Fuzzy logic, Triplets, Similarity values

Article Info

Accepted:
06 September 2018
Available Online:
10 October 2018

A B S T R A C T

A ready-to-eat (RTE) micronutrient rich puffed snack food (S_3) prepared from composite sample of potato mash with five different green leafy vegetable powder and sprouted soya flour. Prepared snack food (S_3) was evaluated along with similar commercial food sample (coded as S_1, S_2, and S_4) for their liking by trained panel members using standard fuzzy logic sensory technique. The developed samples were tested for their quality attributes as colour, flavour, texture and overall acceptability. The responses of the panel members were obtained in terms of not satisfactory, fair, medium, good and excellent. These quality attributes were considered as mathematical variable and based on these variables the fuzzy logic mathematical model was developed. The concept of triplets and values of membership function of standard fuzzy scale was used to determine the overall sensory score of ready to eat snack food samples. As per output given by fuzzy logic model, the samples were ranked excellent, very good, good, satisfactory, fair and not satisfactory. The results nearly close for sample S_2 and S_3 which showed that both samples were rated as very good followed by sample S_4 as good. The colour, flavour, texture and overall acceptability are the strongest (Highly important) quality attributes of RTE snack food sample. Thus, the fuzzy logic technique can be satisfactorily used as analysis tool for sensory evaluation of the puffed RTE snack food.

Introduction

The importance of breakfast is gaining significance in an era of changing life-style, rapid urbanization, convenience and above all, a health-conscious society. The convenience as ready-to-eat (RTE) foods is also becoming popular among the people. Oil fried RTE snack foods are now are getting an interest of consumers due to its convenience, attractive appearance, taste and texture (Euromonitor, 2001). But oil/fat is harmful to health and can responsible for arising many diseases. The oil free puffed snacks are always better for health of people. However, balanced and sufficient nutrition content of available ready-to-eat foods is also a major issue of verification.

To achieve the goal of reducing hunger and malnutrition, it is necessary to make a nutritious food. There is growing concern regarding the nutritive value of foods and to nourish the ever increasing population and the inadequacy of essential nutrients can be improved through fortifications and enrichment of food. Green leafy vegetables

(GLVs) are the micronutrient wealth of India and form an important component of balanced diet. Traditional preparations when modified like potato snacks when incorporated with green leafy vegetables could serve a means of enhancing nutritive value of food. But their use in the diet is limited because of Children who generally dislike eating the green leafy vegetable which creates the deficiency of micronutrients like iron, magnesium, calcium, phosphorus etc. which creates the problem of malnutrition in children. So, the attempt has been made for preparing micronutrient rich RTE snack foods from composite mixture of potato mash, Green leafy vegetables powder and fortifying the same with sprouted soybean by convective heating followed by microwave puffing technique. But one of the biggest challenges for product development is the acceptability by the consumers. Therefore, sensory test is required to predict the consumer acceptability and success of the product. In addition to this, satisfying the demands of the consumers is a major issue in order to succeed in promoting the consumption of functional products. For deciding the consumer choice towards the food products, sensory parameters followed by the nutritional properties are required to be considered. Due to this reason, sensory analysis of any developed food product is an important concern prior to supply the product in the market (Das, 2005; Routray and Mishra, 2011).

Sensory evaluation is an important tool in food industry. Fuzzy logic is an important tool by which imprecise data can be analyzed and important conclusions regarding acceptance, rejection, ranking, strong and weak attributes of food can be drawn (Shinde *et al.,* 2014). In fuzzy modelling, linguistic variables (e.g., not satisfactory, good, excellent, etc.) are used for developing relationship between independent (e.g. color, flavor, texture, overall acceptance etc.) and dependent (e.g. acceptance, rejection, ranking, strong and weak attributes of food) variables (Das, 2005; Routray and Mishra, 2011).

Fuzzy sets used for analysis of sensory data instead of average scores to compare the sample's attribute (Lincklaen *et al.,* 1989; Kavdir and Gayer, 2003). Zadeh (1965) introduced Fuzzy sets theory, which allows uncertain phenomena to be treated mathematically. Chen *et al.,* (1988) developed a model for the analysis of sensory data. Zhang and Litchfield (1991) developed fuzzy comprehensive model for ranking of foods and developing new food products. Multiple experts are involved in subjective evaluation

Ranking of food samples and their quality attributes are based on triplets associated with sensory scales, triplets for sensory score, triplets for sensory score of quality attributes, triplets for relative weightage of quality attributes, triplets for overall sensory score, values of membership function of standard fuzzy scale, values of overall membership function of sensory scores on standard fuzzy scale, similarity values, quality attributes ranking in general.

Sensory evaluation comprises a set of techniques for accurate measurement of human responses to foods and minimizes the potentially biasing effects of brand identity and other information influences on the consumer perception. This method has been successfully applied for mango drinks (Jaya and Das, 2003), dahi powder (Routray and Mishra, 2011), instant green tea powder (Sinija and Mishra, 2011) and soy paneer (Uprit and Mishra, 2002). Millet-based bread (Singh *et al.,* 2012), composite minor millet flour based RTE snack food (Shinde and pawar, 2016) and *Kharodi* (Solanke and Jaybhaye, 2018). Very few researchers have applied fuzzy logic for sensory analysis of RTE dried snack foods. So, the prepared RTE

snack food is compared along with commercial similar food sample for their liking.

Materials and Methods

Preparation of RTE snack food for sensory evaluation

Material was prepared from different mostly used GLVs powder, sprouted soy flour @ 20 % (Pawar, 2017) and binder blended with potato mash. The basic ingredients were to mix together in varied proportion to obtain moisture content liable for cold extrusion through Dolly Mini P3 Pasta Machine (Model: DOLLY, La Monferrina Make, Italy).

The cold extrudate sample was prepared of rectangular shape of 20 mm length, 10 mm width and 1 mm thickness was considered (Dhumal, 2014). For making GLVs based puffed snack product (S_3), cold extrudate sample is puffed at optimised condition of convective heating (120^{o}C for 240 s) followed by microwave puffing (420 W for 60 s).

The data obtained by sensory evaluation of Prepared GLVs based RTE snack food sample,S_3 and three commercial (samples prepared by SHGs) oil free snack coded as S_1 - oil fried RTE snack from rice,S_2-puffed potato snacks and S_4- puffed oil free garlic flavoured snack were analyzed by using fuzzy logic model and Matlab software (Shinde *et al.*, 2014.) A panel of twenty judges selected for sensory evaluation. Panel consist of both male and female judges in the age group of 20 to 50 years (Ranganna, 1987; Singh *et al.*, 2012) belonging to faculty and research scholars of the department were selected on good health, average sensitivity, interests in sensory evaluation and familiarity with snack foods. Judges were familiarized with the definitions of the quality attributes of RTE snack food before sensory evaluation.

The panellists were asked to indicate their preference for each sample based on the selected quality attributes of colour, flavour, texture and overall acceptability by giving tick (√) mark to appropriate respective fuzzy scale factor for each of the quality attributes of the sample after evaluating the samples (Jaya and Das, 2003). They were asked to take two or three pieces of samples before testing them and give the score for flavour first in the score sheet. Also, they were advised to rinse their mouth with lukewarm water between the testing of each sensory character (Das, 2005; Sinija and Mishra, 2011) and between testing the consecutive samples (Jaya and Das, 2003).

The samples were rated as "Not satisfactory", "Fair", "Medium", "Good" and "Excellent". Judges were also instructed to give rank to quality attributes of ready to eat snack food in general, by giving tick (√) mark to the respective scale factors, viz. "Not at all important", "Somewhat important", "Important", "Highly important" and "Extremely important". The set of observations were analyzed using Fuzzy analysis of sensory scores. This method utilizes linguistic data obtained by sensory evaluation. Ranking of the ready to eat food samples was done by using triangular fuzzy membership distribution function. Sensory scores of the ready to eat food samples were obtained by using fuzzy scores given by the judges, which were converted to triplets and used for estimation of similarity values used for ranking of samples (Shinde *et al.*, 2016).

The major steps involved in the fuzzy modelling of sensory evaluation are as follows,

$$Cs_1 = \frac{0(0\ 0\ 25)+1(25\ 25\ 25)+3(50\ 25\ 25)+14(75\ 25\ 25)+2(100\ 25\ 0)}{20}$$

Calculation of overall sensory scores of snack food samples in the form of triplets (Fig. 1);

Estimation of membership functions on standard fuzzy scale (Fig. 2);

Computation of overall membership functions on standard fuzzy scale (Fig. 3).

Estimation of similarity values and ranking of the snack food samples.

Estimation of quality attributes ranking of snack food samples in general.

A program in MATLAB software (trial version) was developed for the calculation of all the above mentioned steps.

Triplets associated with five point sensory scale

The obtained sensory scores were converted into a set of three numbers on five point scale. Snack food samples and quality attributes were assigned fuzzy membership on a five point sensory scale (Das, 2005).

The distribution pattern of five point sensory scale is poor/not at all important, fair/somewhat important, medium/important, good/highly important and excellent/ extremely important as shown in Figure 1.

Set of three numbers known as "triplet" is used to represent triangular membership function on five point scale where triangle "abc" represents membership function for poor/not at all important category, triangle "ade" represents distribution function for fair/somewhat important category, etc. Table 1 shows 'triplets' associated with five point sensory scales.

First number of the triplet denotes the value of abscissa at which the value of membership function is one. Second and third number of the triplet indicates the distance to left and right respectively of the first number where the membership function is zero (Routray and Mishra, 2011).

The triplet for a particular quality attribute of given sample can be obtained from the sum of sensory scores, triplets associated with five point sensory scale and the number of judges.

For example, the colour attribute of a sample, when total number of judges were 20 and out of the total 20 judges, one judges gave 'Fair' score, three judges gave the score as 'Medium', fourteen gave 'Good' and two gave 'Excellent'; the triplets for the sensory scores of colour can be calculated by Eq.1. (1)

Triplets for each quality attribute of all the samples and quality attributes of snack food samples in general were obtained as per Eq. 3.11. Similarly, from the general weightage given by judges to the quality attributes of snack food samples in general, the triplets for relative weightage of quality attributes (Q_{Rel}) were also calculated.

The Relative weightage of the quality attribute for color, flavor, taste and overall acceptability were defined colour as: QCrel = QC/ Qsum, flavor: QFrel = QF/ Qsum, Texture: QTrel = QT/Qsum and for overall acceptability: QOrel = QO/ Qsum, where Qsum is the sum of first digit of triplets of all quality attributes in general.

Triplets for overall sensory scores of *Snack food* samples

The triplets for overall sensory scores of snack food samples were calculated using eq. 2, in which triplet for sensory score for each quality attribute was multiplied with the triplet for relative weightage of that particular attribute and the sum of resultant triplet values for all attributes was taken.

$$SO1 = CS_1 \times QC_{rel} + FS_1 \times QF_{rel} + TS_1 \times QT_{rel} + OS_1 \times QO_{rel} \quad (2)$$

Where, CS_1, FS_1, TS_1 and OS_1 represents the triplets corresponding to the colour, flavour, texture and Overall Acceptability of sample one and QC_{rel}, QF_{rel}, QT_{rel} and QO_{rel} denotes the triplets corresponding to the relative weightage of quality attributes of snack food in general. Using similar Equations the overall scores for all samples were calculated. The multiplication of triplet (a b c) with triplet (d e f) was done by applying a rule as given in Eq. 3.

$$SO1 = CS_1 \times QC_{rel} + FS_1 \times QF_{rel} + TS_1 \times QT_{rel} + OS_1 \times QO_{rel} \quad (3)$$

Membership function for standard fuzzy scale

The triplets obtained by Five Point scale are converted into Six Point sensory scale referred to as Standard Fuzzy scale. The triangular distribution pattern of sensory scales using symbols F1, F2, F3, F4, F5 and F6 is given in Figure 2. Membership function of each of the sensory scales follows triangular distribution pattern where maximum value of membership function is one.

The values of fuzzy membership function lie between 0 and10. Therefore, values of F1 through F6 are defined by a set of 10 numbers as given in Eq. 4.

F_1 = (1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0)
F_2 = (0.5, 1, 1, 0.5, 0, 0, 0, 0, 0, 0)
F_3 = (0, 0, 0.5, 1, 1, 0.5, 0, 0, 0, 0)
F_4 = (0, 0, 0, 0, 0.5, 1, 1, 0.5, 0, 0)
F_5 = (0, 0, 0, 0, 0, 0, 0.5, 1, 1, 0.5)
F_6 = (0, 0, 0, 0, 0, 0, 0, 0, 0.5, 1) (4)

Overall membership function of sensory scores on standard fuzzy scale

The overall quality of the *snack food* samples was linked to the standard fuzzy scale. The overall quality, as expressed by a triplet (a, b, c) was represented by a triangle ABC, shown in Figure 3. The graphical representation of membership function of a triplet (*a*, *b*, *c*) is given in Figure 3. The figure shows that for a triplet (*a*, *b*, *c*), when the value of abscissa is *a*, value of membership function is 1 and when it is less than *a*-*b* or greater than *a*+*c*, the value is 0.

For a given value of *x* on abscissa, value of membership function *Bx* can be expressed by similar triangles as given in eq. 5.

$$B_x = \frac{x-(a-b)}{b} \quad for\ (a-b) < x < a$$

$$B_x = \frac{(a+c)-x}{c} \quad for\ a < x < (a+c)$$

$$B_x = 0\ for\ x < (a-b)\ and\ x > (a+c) \quad (5)$$

For overall sensory quality of each of the samples and for quality attributes of snack food sample in general, the value of membership function *Bx* at *x*=0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 were found out from eq. 5. This membership function value of samples and quality attributes in general on standard fuzzy scale was given as set of 10 numbers which are, '(maximum value of B_x at $0 < x < 10$), (maximum value of B_x at $10 < x < 20$), (maximum value of B_x at $20 < x < 30$), (maximum value of B_x at $30 < x < 40$), (maximum value of B_x at $40 < x < 50$), (maximum value of B_x at $50 < x < 60$), (maximum value of B_x at $60 < x < 70$), (maximum value of B_x at $70 < x < 80$), (maximum value of B_x at $80 < x < 90$), (maximum value of B_x at $90 < x < 100$)'.

Similarity values and ranking of RTE snack food samples

After getting the B values for each sample and quality attribute in general on standard fuzzy scale as a set of 10 values, the similarity values for each triplet of samples and quality attributes were obtained by the eq. 6 (Sinija and Mishra, 2011).

Where, *Sm* is the similarity value for the sample and quality attribute in general, $F \times B'$ is the product of matrix *F* with the transpose of matrix *B*, $F \times F'$ is the product of matrix *F* with the transpose of *F* and $B \times B'$ is the product of matrix *B* with its transpose. For sample one similarity values will be *Sm (F1, B1), Sm (F2, B1), Sm (F3, B1), Sm (F4, B1), (F5, B1) and (F6, B1).* The values were calculated using the rules of matrix multiplication.

Similarity values under the six categories of sensory scales were compared to find out the highest similarity value. The category corresponding to the highest similarity value was considered responsible for its quality. The overall quality of each of the samples was defined using above procedure. By combining the defined overall qualities of the samples as calculated by the above procedure, ranking of three samples and quality attributes in general was done by fuzzy comprehensive modeling (Zhang and Litchfield, 1991).

Results and Discussion

Jaya and Das, (2003) Stated that fuzzy logic can be applied to treat uncertain phenomena mathematically, i.e., expressing the degree of ambiguity in human thinking and relating it to a real number. The fuzzy logic technique converts the linguistic sensory responses obtained from the judges into numerical values which can be applied for comparison of similar products.

The sensory scores as given by the judges have been shown in and Table 2.

Triplets for sensory quality of RTE snack food sample

Table 2 shows the sum of sensory scores according to preferences given by the judges for snack food sample as S_1, S_2, S_3 and S_4.

Triangular membership function distributions of sensory scales were given by "triplets", which are sets of three numbers. Calculation of sensory quality attributes of all RTE snack food samples in triplets form (Column 6 of Table 2) was done from (i) sum of sensory scores given by judges during sensory evaluation, (ii) triplets associated with the sensory scale (Table 1) and (iii) number of judges who gave tick mark under particular head on sensory scale (Table 2). The triplet for a particular quality attribute of given sample was obtained from the sum of sensory scores, triplets associated with five point sensory scale and the number of judges. The results of calculations of triplets for four samples under sensory evaluation are given in Table 2.

$$S_m(F, B) = \frac{F \times B'}{Max\,(F \times F' \text{ and } B \times B')} \quad (6)$$

Triplets for importance of quality attributes in general and relative weightage

The sensory scores given by judges and the triplets for quality attributes in general of snack food sample are given in Table 3. The triplets for individual preference to the importance of quality attributes of snack food in general were calculated using the eq. 1 similar to triplets for three samples.

Thus, the triplets for judges preference to importance of quality attributes, viz., colour (QC), flavour (QF), texture (QT) and overall acceptability (QO) were as given in Table 3 and were denoted as eq. 7.

It is necessary to bring the value of the first digit of overall sensory score between 0 and 100. In order to do this, the values of triplets for quality attributes in Table 3 were reduced by a factor 1/Qsum, where, Qsum is the sum of the first digit of all the triplets which was calculated as given in eq. 8 (Singh *et al.*, 2012).

Fig.1 Triplets associated with five point sensory scales

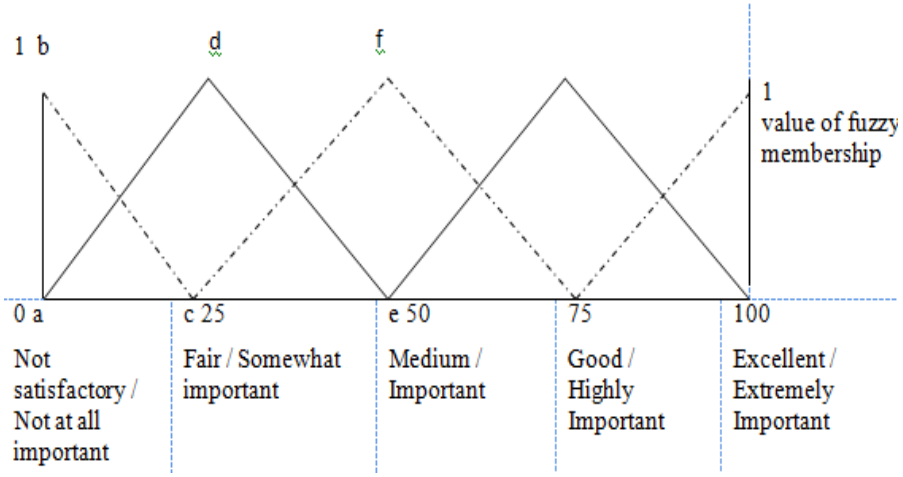

Fig.2 Standard fuzzy scale

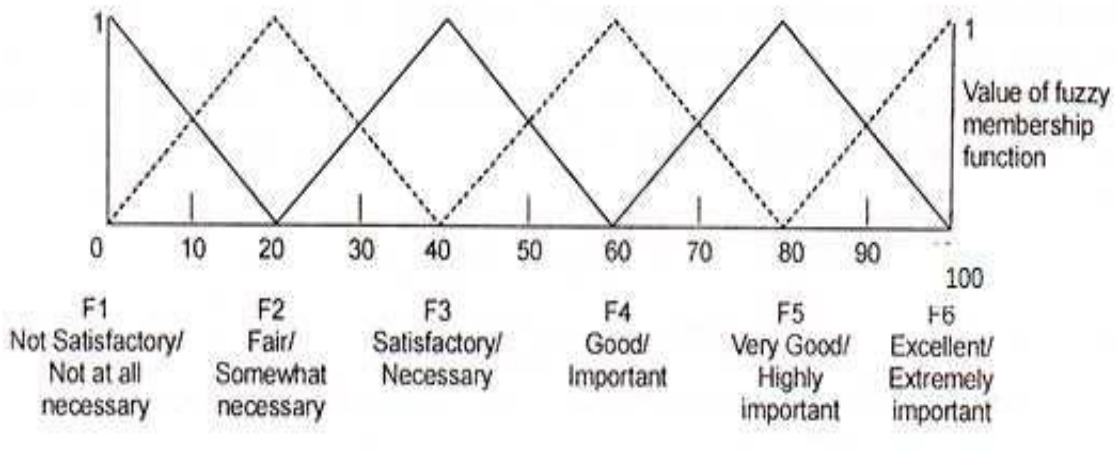

Fig.3 Graphical representation of triplet (a, b, c) and its membership function

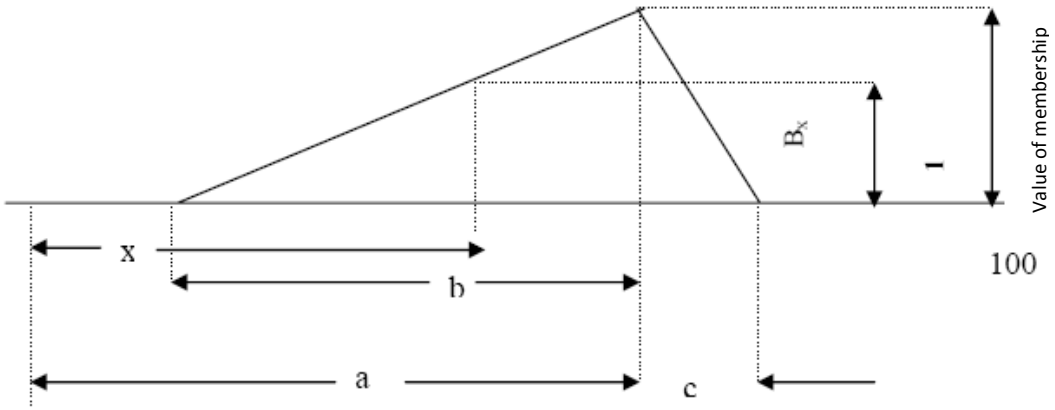

Table.1 Triplets associated with fuzzy logic 5-point sensory scales

Poor/Not at all important	Fair/Somewhat important	Good/ Important	Very good/Highly important	Excellent/ extremely important
0 0 25	25 25 25	50 25 25	75 25 25	100 25 0

Table.2 Sum of sensory scores in terms of preference given by judges and corresponding triplets for sensory quality RTE snack food samples

Sensory quality attributes	Not satisfactory	Fair	Medium	Good	Excellent	Triplets for Sensory Quality of Samples
Colour						
Sample 1	0	1	3	14	2	CS_1 = (71.25 25 22.5)
Sample 2	0	0	4	12	4	CS_2 = (75 25 20)
Sample 3	0	0	6	9	5	CS_3 = (73.75 25 18.75)
Sample 4	0	0	6	12	2	CS_4 = (70 25 22.5)
Flavour						
Sample 1	0	1	5	14	0	FS_1 =(66.25 25 25)
Sample 2	0	2	5	8	5	FS_2 =(70 25 18.75)
Sample 3	0	1	3	12	4	FS_3 =(73.75 25 20)
Sample 4	0	1	2	14	3	FS_4 = (73.75 25 21.25)
Texture						
Sample 1	0	1	4	12	3	TS_1 =(71.25 25 21.25)
Sample 2	0	1	1	10	8	TS_2 =(81.25 25 15)
Sample 3	0	0	0	9	8	TS_3 =(73.75 21.25 11.25)
Sample 4	0	0	0	13	1	TS_4 = (53.75 17.5 16.25)
OAA						
Sample 1	0	0	4	14	2	OS_1 =(72.5 40 117.5)
Sample 2	0	0	2	11	7	OS_2 =(86.25 27.5 18.75)
Sample 3	0	0	2	15	3	OS_3 =(81.25 25 16.25)
Sample 4	0	0	7	11	2	OS_4 =(68.75 25.85 68.75)

Table.3 Sum of sensory scores in terms of preferences given by judges and triplets for Importance of quality attributes of RTE snack food in general

Quality attributes	Sensory scale factors					Triplets for Quality attributes
	NI	SI	I	HI	EI	
Colour	0	0	6	8	6	QC = (75 25 17.5)
Flavour	0	0	3	11	6	QF = (78.75 25 17.5)
Texture	0	0	2	8	10	QT = (85 25 12.5)
OAA	0	0	5	8	7	QO = (77.5 31.25 16.25)
						Qsum = 316.25

NI- Not Important, SI- Slightly Important, I- Important, HI- Highly Important, EI- Extremely `Important

Table.4 Similarity values of RTE snack food samples and their ranking

Sensory scale	Sample 1 (Oil fried RTE snack from rice)	Sample 2 (Puffed commercial potato snacks)	Sample 3 (GLVs fortified oil free potato snack)	Sample 4 (Garlic flavoured RTE snack)
Poor	0.0044	0.0000	0.0000	0.0000
Fair	0.1096	0.0553	0.0609	0.1059
Medium	0.3544	0.3798	0.3176	0.4070
Good	0.5927	0.4453	0.6406	**0.6715**
Very good	**0.6097**	**0.7206**	**0.7129**	0.5977
Excellent	0.2496	0.3002	0.2697	0.2097
Ranking	III	I	II	IV

Table.5 Similarity values of quality attributes of RTE snack food sample in general

Sensory scale	Colour	Flavour	Texture	Overall Acceptability
Not at all Important	0.0000	0.0000	0.0000	0.0000
Somewhat Important	0.0000	0.0000	0.0000	0.0000
Important	0.0000	0.0540	0.0000	0.1330
Very Important	0.3200	0.5760	0.3200	0.4960
Highly Important	**0.9428**	**0.9597**	**0.9201**	**0.9182**
Extremely Important	0.5256	0.3203	0.5092	0.2560
Ranking	II	I	III	IV

$$Qsum = 75 + 78.75 + 85 + 77.5$$

$BS_1 = (0\ 0.0389\ 0.2300\ 0.4211\ 0.6122\ 0.8033\ 0.9825\ 1\ 0.8387\ 0.6725)$

$BS_2 = (0\ 0\ 0.0738\ 0.2660\ 0.4583\ 0.6506\ 0.8428\ 1\ 0.9455\ 0.6487)$

$BS_3 = (0\ 0\ 0.0794\ 0.2815\ 0.4835\ 0.6855\ 0.8875\ 1\ 0.8601\ 0.5444)$

$BS_4 = (0\ 0\ 0.2050\ 0.4244\ 0.6437\ 0.8631\ 1\ 0.9172\ 0.6971\ 0.4771)$ (10)

$= 316.25$ (7)

The triplets for relative weightage of the quality attributes for colour, flavour, texture and overall acceptability were calculated as:

$$QCrel = (0.2371,\ 0.07905,\ 0.0553)$$
$$QFrel = (0.2490,\ 0.07905,\ 0.0553)$$
$$QTrel = (0.2687,\ 0.07905,\ 0.0395)$$
$$QOrel = (0.2450, 0.09881, 0.05138)\ (8)$$

Overall sensory scores as triplets for RTE snack food samples

The overall sensory scores triplets for snack food samples were calculated as the sum of the products of the triplets for snack food samples and relative weightages given in Table 2 and eq. 8 using eq. (2) and triplet multiplication rule given in eq. (3).

The calculated values of triplets for overall sensory scores of Sample 1 (SOS_1), Sample 2 (SOS_2), Sample 3 (SOS_3) and (SOS_4) are as follows:

$$SOS_1 = (70.297 \quad 52.335 \quad 60.200)$$
$$SOS_2 = (78.175 \quad 52.014 \quad 33.694)$$
$$SOS_3 = (75.572 \quad 49.505 \quad 31.674)$$

$$SOS_4 = (66.247 \quad 45.593 \quad 45.441) \ (9)$$

From the first digit values in triplets for four samples it can be inferred that people have preferred sample 2 and sample 3 over sample 1 and sample 4. As sample 2 is snack from potato simply and sample 3 is oil free puffed GLVs fortified potato snack food were prepared. GLVs powder improves the sensory and nutritional quality of snack.

Membership function of overall sensory scores on standard fuzzy scale

Overall membership functions for triplets of Sample 1, Sample 2, Sample 3 and sample 4 on standard fuzzy scale were calculated by using the eq. 5 and values in eq. 9. These values (B1 to B10) are called as fuzzy membership values and are given in eq. 10 as:

Similarity values and ranking of RTE snack food samples

The similarity values were calculated by comparing the membership function values (BS_1, BS_2, BS_3, BS_4) of four samples in eq. 10 with their corresponding F1 to F6 values in eq. 4.

The ranking of samples was done on the basis of obtained similarity values under not satisfactory (*F1*), Fair (*F2*), Medium (*F3*), Good (*F4*), Very good (*F5*) and Excellent (*F6*) categories. The similarity values for all the four samples under different scale factors are presented in Table 4.

From the Table 4, it can be seen that, for Sample 1, Sample 2 and Sample 3 the highest similarity value lies in the category "very good" i.e. 0.6097, 0.7206 and 0.7129 respectively. For Sample 4, highest similarity value is obtained under the category "good" i.e 0.6715 On comparison of highest similarity values, their ranking was done as Sample 2 & 3 > Sample 1 > sample 4 where Sample 2 is oil free potato snack, Sample 3 is oil free puffed GLVs based potato snack food, Sample 1 is oil fried RTE snack from rice and sample 4 is garlic flavoured RTE snack Thus, it indicates that Sample 2 was preferred by judges. Also, the score of sample 3 and 1 was very close to that of sample 4 under the category of "good". Therefore, present method of fortification by GLVs into potato snack is similar to the commercial snack food and improves the sensorial and nutrition property of RTE snack food hence it is value added process. Similar ranking under the category "very good" was obtained by Shinde *et al.,* (2016) for RTE snack food prepared from composite minor millet flour with and without incorporation of sprouted soybean and by Solanke *et al.,* (2018) for "Kharodi" with or without addition of sesame.

Fuzzy membership function of quality attributes in general on standard fuzzy scale

The same method as described previously was used for quality attribute (colour, flavour, texture and overall acceptability) ranking of RTE snack food in general. The triplets for importance of these quality attributes in general have been given in Table 3. Using the above method of computation and denoting BC, BF, BT and BO as overall sensory scores on standard fuzzy scale for membership function of colour, flavour, texture and overall acceptability respectively, we get,

$$BC = (0,0,0,0,0,0,0.4,0.8,1,0.7)$$
$$BF = (0,0,0,0,0,0.2,0.6,1,0.9,0.3)$$
$$BT = (0,0,0,0,0,0,0.4,0.8,1,0.6)$$
$$BO = (0,0,0,0,0.1,0.4,0.7,1,0.8,0.2) \ (11)$$

The similarity values of four quality attributes of the RTE snack food were calculated by eq. 6 using the F values in eq. 4 and B values in

eq. 11. The computed values are given in Table 5.

The results from Table 5 show that all quality attributes can be considered as highly important for RTE snack food as general. Table 5 shows that flavour (0.9597) has highest quality attributes value followed by colour (0.9428), Texture (0.9201) and overall acceptability (0.9182). The order of preference given by judges for quality attributes of RTE snack food in general was Flavour (highly important) > Colour (highly important) > Texture (highly important) > Overall acceptability (highly important).

The similarity values of all quality attributes are close to each other and are highly important for RTE snack food. The close tie between two to three quality attribute indicates the well-established consumer choice and product. It can be concluded that the fuzzy logic analysis can be used for sensory evaluation of RTE snack food and the (sample 2) product can be ranked based on consumer preference. It can be concluded that (Sample 3) GLVs fortified potato snack has close tie with sample 2 which shows that consumer preference is good for sample 3 also. The results of sensory analysis showed that the addition of GLVs powder in RTE snack food make it micronutrient rich. Considering the importance of oil free food, GLVs based RTE potato snack food considered as suitable for human health.

References

BIS, 1971. Guide for sensory evaluation of foods. Optimum requirements IS: 6273 (Parts-II). New Delhi: Bureau of Indian Standards.

Chen, S.M. 1988. A new approach to handling fuzzy decision making. IEEE Transactions on Systems, Man and Cybernetics, 18: 1012-1016.

Das, H. 2005. Food Processing Operations Analysis. Asian Books Pvt. Ltd. New Delhi, pp. 357-402.

Jaya, S., and Das, H. 2003. Sensory evaluation of mango drinks using fuzzy logic. Journal of Sensory Studies, 18:163–176.

Jayebhaye, R.V. 2012. Development of hot air puffing machine for preparation of millet based RTE snack food. Unpublished Ph. D thesis, Agricultural and Food Engineering Department, IIT, Kharagpur (W.B.)-721302, India.

Kavdir, I., and Gayer, D.E. 2003. Apple grading using Fuzzy logic. Turkish Journal of Agriculture, 27: 375-382.

Lincklaen, W., Westenberg, S.D., Jong, D.A., Meel, J.F.A., Quadt, E., and Duin, R.P.W. 1989. Fuzzy set theory applied to product classification by a sensory panel. Journal of Sensory Studies, 4(1): 55-72.

Malleshi, N.G. 1986. Processing of small millets for food and industrial uses. In Proceeding of first international small millet workshop, Banglore, October 29 to November 2, 1986 (pp. 321 - 324). Oxford and IBH.

Mazumdar, P., Roopa, B.S., and Bhattacharya, S. 2007. Textural attributes of a model snack food at different moisture contents. Journal of Food Engineering, 79:511-516.

McGarrity, S. 2008. Introduction to object-oriented programming in MATLAB®, Matlab Digest. www.mathworks.com.

Pawar, S.G. (2017) Development of sprouted soy fortified millet flour based ready-to-eat snack using microwave puffing technique, Unpublished Ph.D. thesis, dept. of Agril. process engineering, Dr. PDKV, Akola India-444001.

Ranganna, S. 1987. Handbook of analysis and quality control for fruit and vegetables products, Tata McGraw Hill. Pp. 156 – 196.

Rao, M.A. 1986. Rheological properties of fluid foods. In M.A. Rao, and S.S.H. Rizvi (Eds.), Engineering properties of foods. New York: Marcel Dekker INC., pp. 1 – 48.

Routray, W., and Mishra, H.N. 2011. Sensory evaluation of different drinks formulated from dahi (Indian yogurt) powder using fuzzy logic. Journal of Food Processing and Preservation,

Shinde, K.J., and Pardeshi, I.L. 2014. Fuzzy logic model for sensory evaluation of commercially available jam samples. Journal of Ready to Eat Food, 01(02): 78-84.

Shinde, K.J., Pardeshi, I.L., Pawar, S.G., and Gajakos, A.V. 2016. Applications of fuzzy logic technique in sensory evaluation of ready to eat foods. Journal of Ready to Eat Food, 03 (04): 45-50.

Singh, K.P., Mishra, A., and Mishra, H.N. 2012. Fuzzy analysis of sensory attributes of bread prepared from millet-based composite flours. *LWT* - Food Science and Technology, 48 (02): 276-282.

Sinija, V.R., and Mishra, H.N. 2011. Fuzzy analysis of sensory data for quality evaluation and ranking of instant green tea powder and granules. Food and Bioprocess Technology, 4: 408–416.

Solanke, S.B., R.V. Jaybhaye and Jadhav, S.B. 2018. Sensory Evaluation of Pearl Millet based Snack Food (*Kharodi*) using Fuzzy Logic. *Int.J.Curr. Microbiol.App.Sci.* 7(04): 2144-2154.

Uprit, S., and Mishra, H.N. 2002. Fuzzy multi attribute decision making approach and comparison of soya fortified paneer. *Journal of Sensory* Studies, 17(2): 163-176.

Vincent, J. F. V. 1998. The quantification of crispness. Journal of Science of Food and Agriculture, 78: 162–168.

Zadeh, L. 1965. Fuzzy sets: Information and control, 8: 338–353.

Zhang, Q., and Litchfield, J.B. 1991. Applying fuzzy mathematics to product development and comparison. Food Technology, 45(7): 108–115.

How to cite this article:

Deshmukh, S.D., I.L. Pardeshi, S.B. Solanke and Shinde, K.J. 2018. Sensory Evaluation of Ready to Eat Snack Food Using Fuzzy Logic. *Int.J.Curr.Microbiol.App.Sci.* 7(10): 551-562.
doi: https://doi.org/10.20546/ijcmas.2018.710.061