FUZZY LOGIC SENSORY EVALUATION OF CUPCAKES DEVELOPED FROM THE MAHUA FLOWER (MADHUCA LONGIFOLIA)

Vinti Singh[1], Sandeep Kumar[2], Jyotsana Singh[3] and A. K. Rai[4]
[1, 3]Centre of Food Technology, IPS, University of Allahabad, Allahabad-211002, India
[2]Department of Physics, H.N.B Government PG College, Naini, Allahabad-211008, India
[4] Department of Physics, University of Allahabad, Allahabad-211002, India

Abstract: In this paper, sensory scores of five samples of cupcake, including control one, prepared from different percentage of mahua flower syrup at various baking temperatures is investigated. The samples are ranked for their quality attributes. For this, a panel of fifteen judges performed the sensory evaluation of cupcake samples. Both ranking and desirable quality characteristics of the samples 'in general' were analyzed with fuzzy logic sensory analysis. The quality attributes which affected the acceptability of samples were color, flavor, texture, overall acceptability (OAA) and taste. The order of preference of quality attributes for cupcake in general were OAA > taste > flavor > texture > color. Thus analysis indicates that - taste, OAA and flavor were major quality attributes while texture and color were the least important sensory quality attributes for a cupcake. Also a cupcake with 100% replacement of sugar with mahua flower syrup was the most acceptable by fuzzy logic sensory analysis.

Keywords: Fuzzy logic sensory analysis, Mahua cupcake, Control cupcake, overall acceptability

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. Mahua flower (*Madhuca longifolia*) is considered as a “boon” for good health since the ancient times [1]. Mahua flower syrup 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, vitamin B6 and soluble fibre [1-3]. About 40-70% sugar content is reported by different scientists in samples (Mahua) collected from different geographical region [4]. These results show the potential of mahua flowers to be used as a novel source of natural sweetener. Moreover mahua flower has shown the presence of abundant polyphenolic compounds [5]. Though it is easily available 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 products was greatly felt and its processing in the form of a cupcake was thought to be an effective way to include mahua flower in the diets of humans of all age groups.

Sensory evaluation is the field in which human senses like; sight, taste, touch, smell and hearing etc. are basic tools to gain the information about the product. The sensory characteristics of food cannot be assessed precisely in a quantitative form but in a qualitative sense. So the information acquired by human senses is always uncertain and imprecise. This causes problem in modeling and management of uncertain knowledge using sensory evaluation process [6]. Generally, subjective evaluation is done for the sensory data like color, flavor, texture, taste and overall acceptability (OAA) of the products and these data are analyzed statistically [7]. Acceptance or rejection of any food product is not possible which is based on these inquiries of the strength and weakness of specific sensory attribute. Fuzzy’s implementation in food quality control for the food industry has been the focus of different researchers. The reasoning process of sensory evaluation is expressed in linguistic terms of operators and experts [8]. Thus the uncertain and vague information in this type of problem, the linguistic decision analysis to sensory evaluation can be used to model and manage [6]. It is the critical criterion for judging the quality of food. It is used at several stages of new product development and for comparison of similar type of products.

For comparing a developed product with similar prepared products, fuzzy logic is an important decision-making tool. Fuzzy sets can be used for the analysis of sensory data instead of average scores to compare the samples attributes [9, 10]. 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. Thus fuzzy logic is used in low and high ranking of products evaluated by the judges and to determine the importance of individual factors to the overall quality of a product. According to many researchers fuzzy logic is a useful tool for the sensory analysis and quality ranking of many food products like mango drink [11], coffee [12], dahi (Indian yoghurt) [13], jam samples [14], aromatic foods packed in developed starch based films [15], various other food product development [16] and recently kendu jam [17].

In this article, the sensory properties of cupcakes obtained by mahua flower syrup, with different combinations, were compared with the standard sugar cupcake. The model is developed on the basis of sensory score given by a panel of especially trained fifteen judges to the cupcake sample with different quantity combinations of mahua syrup, baking time and baking temperature. The study demonstrates the usefulness of the developed fuzzy model in optimization and ranking of the cupcake samples and in finding out the strongest and the weakest quality attributes of cupcake. In addition to this, satisfying the demands of the consumers is a major issue in order to succeed in promoting the consumption of functional food 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 [13]. So the highlighting factors of this study were utilization of mahua flower syrup in cupcake.

II Materials and Method

2.1 Flow chart for preparation of *Mahua cupcake*

The study aimed to develop a mahua cupcake with maximum possible amount of mahua syrup using response surface methodology (RSM), one of the most commonly used optimization techniques in food science. A total of 20 experiments were performed and 5-points repeated at central point. Each experiment was repeated twice on two samples prepared independently. They were coded as CC1, CC2 upto CC20. The flowchart for the preparation of cupcake is given as

Mix butter and SMP properly

↓

Add shifted refined flour and baking powder into mixture of butter SMP

↓

Add prepared mahua syrup (70°B)

↓

Then add milk

↓

Add vanilla extract and beat this batter properly till it become smooth

↓

Transfer into the muffin moulds

↓

Microwave for 10 minute at 150-200°C

↓

Cool it at room temperature

↓

Stored in air tight container

2.2 Sensory evaluation for mahua cupcake

Four highly overall acceptability scored mahua cupcake samples were chosen from RSM formulations. By fuzzy logic model, these samples are compared with control cupcake sample which is prepared by sugar instead of mahua syrup. Thus total five samples of cupcake were chosen for analysis of fuzzy logic from different formulation of response surface design; they were coded as control cupcake, CC10, CC13, CC15, CC9. Formulations were for CC9, mahua flower syrup content 21.36 g, baking time 14 min, baking temperature 175 ^{0}C; for CC10, mahua flower syrup content 88.64g, baking time 14 min, baking temperature 175 ^{0}C; for CC13, mahua flower syrup content 55 g, baking time 14 min, baking temperature 135 ^{0}C; for CC15, mahua flower syrup content 55 g, baking time 14 min, baking temperature 175 ^{0}C. A panel of 15 judges was selected for sample study purpose who have good health, interest in sensory evaluation, ability to concentrate and learn and familiarity with cupcake. The researchers have reported the involvement of expert judges [18] for better utility of the fuzzy logic technique for sensory evaluation.

2.3 Fuzzy analysis of sensory data for ranking of mahua cupcake

In fuzzy theory, a subject can be represented by fuzzy sets with a series of elements and their membership degrees compared to crisp sets without membership [19]. Such fuzzy sets provide the mathematical methods that can represent the uncertainty of human's expressions [12]. Sensory evaluation is the ultimate criterion for acceptance or rejection of food [20] especially commercially available foods like cupcake. Sensory quality of food can be evaluated from an estimation of total impression the food creates in the mind of person who consumes it [21, 22].

2.4 Quality attributes selected for sensory evaluation

Quality attributes selected for sensory evaluation of mahua cupcake were: *color, flavor, texture, taste* and *overall acceptability* (OAA). Judges were familiarized with quality attributes of samples before the actual sensory evaluation. They were advised to take two short sniffs of samples before tasting them and give the score for flavor first in scorecard (Appendix). They were also advised to rinse their mouth with water between testing the consecutive samples [11]. Judges were instructed to give tick (√) mark to appropriate respective fuzzy scale factor for each of the quality attributes of the sample after evaluating the samples. The samples were rated as "Poor", "Fair", "Medium", "Good" and "Excellent". Judges were also instructed to give rank to quality attributes of samples in general, by giving tick (√) mark to the respective scale factors (Appendix), viz. "Not important", "Somewhat important", "Important", "Highly important" and "Extremely important". The set of observations were analyzed using fuzzy analysis of sensory scores. This method has been successfully applied for mango drinks [11], dahi powder [13], instant green tea powder [23] and bread prepared from millet-based composite flours [19]. Ranking of the cupcakes samples was done by using triangular fuzzy membership distribution function, which has been explained in detail by Das [24]. Sensory scores of the samples were obtained by using fuzzy scores given by the judges, which were converted to triplets. The triplets were used for the evaluation of overall membership functions and these functions are utilized in the estimation of similarity values that determines the ranking of the samples.

As given in Figure 1 the major steps involved in the fuzzy modeling of sensory evaluation were (i) calculation of five point sensory scores of samples in the form of triplets and finally overall sensory score triplets of each sample (viz., SO1, SO2, SO3, SO4, SO5); (ii) estimation of fuzzy ten numbered membership function based on six point standard fuzzy scale (viz., F1, F2, F3, F4, F5, F6); (iii) computation of ten numbered overall membership function (viz. B1, B2, B3, B4, B5) for the overall sensory score triplets of the respective samples (viz., SO1, SO2, SO3, SO4, SO5); (iv) estimation of similarity values and ranking of the cupcake samples; and (v) quality attribute ranking of cupcake samples in general. A MATLAB program of sensory evaluation is given by Das [24].

2.5 Triplets associated with sensory scales

A set of three numbers is known as "triplet" that is used to represent triangular membership function distribution pattern of sensory scales. The distribution pattern of 5-point sensory scales consists of "Not satisfactory/Not at all important/Poor (0, 0, 25)", "Fair/Somewhat important (25, 25, 25)", "Medium/Important (50, 25, 25)", "Good/Highly important (75, 25, 25)" and "Excellent/Extremely important (100, 25, 0)" (Figure 2). The three numbers shown in the brackets with the 5-point sensory scales are the triplets. Here the first number of the triplet denotes the coordinate of the abscissa where the value of the membership function is 1 (Figure 2). Second number of the triplet denotes the distance of the first number to the point where the membership function is 0 on to the left hand side of first number. Similarly, third numbers of the triplet designate the distance to the right, of the first number where the membership function is zero [13]. As for example, in Figure 2, triangle a b c represents membership function for 'poor / not at all important' category, and triangle a c_1 d represents distribution function for 'fair / somewhat important' category, etc. Table 1 represents the triplets associated with five-point sensory scales.

2.6 Triplets for sensory scores of cupcake samples and overall quality

For a particular sample, the triplet corresponding to a particular quality attribute (color, flavor etc.) can be obtained from the sum of sensory scores, triplets associated with sensory scale and the respective number of judges (Table 1). For example, the color attribute of second sample (CC10) when out of the total 15 judges, one judge gave "fair" score, four gave the score as "good" and ten gave "very good", the triplet for the sensory score for the color of second sample (CC10) will be given as follows:

$$S2C = \frac{0\,(0\ 0\ 25) + 1(25\ 25\ 25) + 4\,(50\ 25\ 25) + 10\,(75\ 25\ 25) + 0\,(100\ 25\ 0)}{(0 + 1 + 4 + 10 + 0)} = (65\ \ 25\ \ 25) \quad (6)$$

Similar values were obtained for every quality attribute (color, flavor, texture, overall acceptability and taste) of all the five samples (control cupcake as sample 1, CC10 as sample 2, CC13 as sample 3, CC15 as sample 4, CC9 as sample 5). Similarly, from the general weightage given by judges to the quality attributes of mahua samples in general, the triplets for sensory score of quality attributes were also calculated (Table 3). To find out the triplets for overall sensory scores of samples, 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. For example, the overall sensory score in the form of triplet for sample 1 (i.e. control cupcake) is given by

$$SO1 = S1C \times QC_{rel} + S1F \times QF_{rel} + S1T \times QT_{rel} + S1O \times QO_{rel} + S1t \times Qt_{rel} \quad (7)$$

where, S1C, S1F, S1T, S1O and S1t represent the triplets corresponding to the color, flavor, texture, overall acceptability and taste respectively of the first sample; and QC_{rel} , $QF_{rel,}$ $QT_{rel,}$ $QO_{re\,,}$ Qt_{rel} denote the triplets corresponding to the relative weightage of quality attributes of samples in general. Using similar equations, the overall scores for all the five samples were calculated. The rule applied for multiplication of triplet (a b c) with triplet (d e f) is given by the following equation

$$(a\ b\ c) \times (d\ e\ f) = (a \times d \quad a \times e + d \times b \quad a \times f + d \times c) \quad (8)$$

2.7 Membership function for standard fuzzy scale

Figure 3 shows triangular distribution pattern of a six-point sensory scale, which is referred to as standard fuzzy scale. The six membership functions F1, F2, F3, F4, F5, and F6 were used for standard fuzzy sensory scale. Membership function of each of the sensory scales follows triangular distribution pattern where maximum value of membership function is 1 (at x=a). Values of membership functions are defined by a set of ten numbers as follows:

F1 = {1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0} for 'Not satisfactory/Not at all'
F2 = {0.5, 1, 1, 0.5, 0, 0, 0, 0, 0, 0} for 'Fair / Somewhat necessary'
F3 = {0, 0, 0.5, 1, 1, 0.5, 0, 0, 0, 0} for 'Satisfactory / Necessary'
F4 = {0, 0, 0, 0, 0.5, 1, 1, 0.5, 0, 0} for 'Good / Important'
F5 = {0, 0, 0, 0, 0, 0, 0.5, 1, 1, 0.5} for 'Very Good / Highly Important'
F6 = {0, 0, 0, 0, 0, 0, 0, 0, 0.5, 1} for 'Excellent / Extremely Important' (9)

2.8 Overall membership function of sensory scores on standard fuzzy logic scale

Overall membership function are assigned as B1, B2, B3, B4 and B5, for the overall quality triplet of all the five samples; SO1, SO2, SO3, SO4 and SO5 respectively. These overall membership functions, B's will be given a set of ten numbers, like F's. To calculate them, we use graphical representation of membership function of a triplet (a, b, c) as shown in Figure 4. 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. In mathematical form, for a given value of x on abscissa, value of membership function B_x can be expressed as:

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

$$B_x = \frac{(a + c) - x}{c} \quad \text{for } a < x < (a + c) \quad (10)$$

$$B_x = 0 \text{ for } x < (a - b) \text{ or } x > (a + c)$$

The ten numbers of B 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) ". Thus, for each of the five samples, the value of membership function B_x for x values 0 – 10,10 - 20, 20 - 30, 30 - 40, 40 - 50, 50 - 60, 60 - 70, 70 - 80, 80 - 90, and 90 - 100 can be found out from Eq. 10.

2.9 Similarity values and ranking of mahua samples

After getting the overall membership function (B's) for the overall quality of all the five samples, the similarity values for each sample were obtained by the equation:

$$S_m\{F, B\} = \frac{F \times B^T}{Max\{F \times F^T \text{ and } B \times B^T\}} \quad (11)$$

Where S_m is the similarity value for the sample / quality attribute under consideration, and B^T, F^T denotes transpose of B and F respectively. Using the rules of matrix multiplication, the values are calculated. Thus, for first sample, Sm (F1, B1), Sm (F2, B1), Sm (F3, B1), Sm (F4, B1), Sm (F5, B1), and Sm (F6, B1) were calculated. Similarity values under the six categories of standard sensory scales were compared to find out the highest similarity value of each sample. The category corresponding to the highest similarity value of a sample was considered as the most responsible for the sample quality. For example, if out of these six similarity values for the second sample, value of Sm (F4, B2) is found to be the highest, the overall quality of that sample was regarded as "good" because six point standard membership function F4 falls in 'good / important category'. Using similar procedure, the overall quality of each of the samples was defined. By combining the obtained overall qualities of the samples as calculated by the above procedure, all the five samples were ranked.

2.10 Similarity values for quality attribute ranking of mahua samples in general

The same method as described previously was used for the quality attribute ranking of samples in general and also for quality attribute ranking of individual samples. Using the overall sensory scores as triplets of the five quality attributes (viz., color, flavor, texture, overall acceptability and taste) and the six membership functions on standard fuzzy scales (F's), similarity values for each of the quality attributes were calculated. By comparing the similarity values for each of the five quality criteria (viz., color, flavor, texture, overall acceptability and taste), the highest similarity value category was found out. The category (viz., Not at all necessary, Somewhat Important, Necessary, Important, Highly Important and Extremely Important) corresponding to the highest similarity value was regarded as the best quality criteria for mahua samples in general. The order of ranking of the quality attributes of mahua samples in general was then determined which is based on the order of the highest similarity values and its corresponding category of the five qualities attributes. For the whole analysis, we have developed an Excell program for fuzzy logic evaluation of sensory data.

III Results and Discussion

3.1 Fuzzy Analysis of sensory data for quality evaluation and ranking of mahua cupcake samples

Table 2 shows the sensory scores of the cupcake prepared from the syrup of fresh mahua flower (sample CC10, CC13, CC15, and CC9) and a control cupcake prepared by sugar. Using Eq. 6 triplets associated with these sensory scores were calculated with the help of triplets associated with five point sensory scales (Table 1) and the sensory scores given by the judges. The sensory scores considered for quality attributes in general were; not at all important (NI), somewhat important (SI), Necessary (N), important (Im), highly important (HI), and extremely important (EI). Triplets for sensory scores of quality attributes, namely color, flavor, texture, overall acceptability and taste, for cupcake samples in general were calculated in the similar manner as for sensory scores of made cupcake samples (Table 3). Sensory scores and the triplets associated with these scores for the quality criteria of cupcake in general and the relative weightage are presented in Table 3. For estimation of overall sensory scores of each of the samples, Eq. 7 was employed. The values of triplets for sensory scores of made samples and relative weightages of the quality attributes were multiplied, which follow the rule of multiplication of triplets mentioned in Eq. 8. For example, triplets for overall sensory scores of control cupcake i.e., sample 1 (SO1) are:

SO1 = (80.00 25.00 20.00) x (0.141 0.070 0.066)
+ (78.33 25.00 25.00) x (0.188 0.070 0.061)
+ (78.33 25.00 21.666) x (0.193 0.070 0.061)
+ ((76.66 25.00 23.33) x (0.235 0.070 0.038)
+ (76.66 25.00 23.33) x (0.244 0.070 0.033) (12)

Triplets for overall sensory scores of other samples viz., CC10 (SO2), CC13 (SO3), CC15 (SO4), and CC9 (SO5) were calculated in a similar manner which is presented below

SO1 = (77.769 52.464 42.449)
SO2 = (65.892 48.122 40.735)
SO3 = (65.682 48.151 41.277)
SO4 = (77.793 52.347 41.314)
SO5 = (66.729 48.708 42.065) (13)

3.2 Overall membership functions of sensory scores on standard fuzzy scale

Six-point sensory scale, viz., not satisfactory/not at all necessary, fair/somewhat necessary, medium/necessary, good/important, very good/highly important, excellent/ extremely important, referred to as 'standard fuzzy scale' and designated as F1, F2, F3, F4, F5, and F6, respectively, were used in the evaluation of sensory scores. Membership function values for the standard fuzzy scale have been presented in Eq. 9. Values of overall membership function of sensory scores of the samples on standard fuzzy scale, Bx, were calculated using Eq. 10. For instance, the triplets for overall sensory scores of sample 1 (SO1) was calculated to be (77.769 52.464 42.449), i.e., a= 77.769, b= 52.464, and c=

42.449, from Eq. 13. Clearly, a-b= 25.305, so Bx=0 for $x < 25.305$, i.e., for $0 < x < 10$ & $10 < x < 20$, Bx=0. Also, Bx=1 (maximum) at x=77.769, so Bx=1, for $70 < x < 80$. Using these values of a, b and c in Eq. 10, the ten values of B i.e., maximum of Bx in the interval 0<x<10, 10<x<20, 20<x<30, 30<x<40, 40<x<50, 50<x<60, 60<x<70, 70<x<80, 80<x<90 and 90<x<100 was found to be 0, 0, 0.0895, 0.2801, 0.4707, 0.6613, 0.8519, 1.0000, 0.9475 and 0.7119 respectively. So, B1=(0 0 0.0895 0.2801 0.4707 0.6613 0.8519 1.0000 0.9475 0.7118). Overall membership functions of sample 2 (CC10), sample 3 (CC13), sample 4 (CC15) and sample 5 (CC9) were calculated by similar method. These values are given in Table 4.

Similarity values of cupcake samples were calculated using the values of membership functions (F's) of standard fuzzy scale and overall membership function (B's) values of sensory scores. The ranking of a cupcake sample was done by combining both the highest similarity value and the particular category (Not at all important, Somewhat important, Necessary, Important, Highly Important, Extremely Important) in which the largest similarity value belongs. Equation 11 was used for the calculation of similarity values. As an example, for sample 1 whose overall membership function on standard fuzzy scale is B1 (Table 4), to calculate similarity value under category "Not at all Important (F1)", $F1 \times B1^T$, $F1 \times F1^T$, and $B1 \times B1^T$ were calculated by applying rules of matrix multiplication. The maximum value among $F1 \times F1^T$ and $B1 \times B1^T$ was taken in the denominator and the value of $F1 \times B1^T$ was taken in the numerator of Eq. 11, and the similarity value under F1 (not satisfactory) is found to be 0.00. Likewise, similarity values under other categories F2 (fair), F3 (satisfactory), F4 (good), F5 (very good), and F6 (excellent) are obtained for sample 1. The similarity values for all five samples under different scale factors were presented in Table 5. From column 2 and 5 of Table 5, it is observed that the highest similarity values for sample 1 (control) and sample 4 (CC15), lies in the category 'very good'. For sample 2 (CC10), sample 3 (CC13) and sample 5 (CC9), the highest similarity values were obtained under category 'good'. In the 'very good' category, the highest similarity value of sample 1 (control) (0.7043) is less than that of sample 4 (CC15) (0.7063). For the other three samples, the highest similarity values lying in the same 'good' category and their order is CC10 (0.6824) > CC13 (0.6808) > CC9 (0.6698). A comparison of the highest similarity values for all the samples along with the consideration of corresponding categories, the ranking was done as sample 4 viz. CC15 > sample 1 viz. control > sample 2 viz. CC10 > sample 3 viz. CC13, > sample 5 viz. CC9. Note that samples CC15, CC10, CC13 and CC9 are the cupcakes prepared by mahua flower syrup using the response surface design while sample control is the cupcake prepared by recipe where sugar is used. Thus, the results indicate that the cupcake sample optimized with response surface methodology preferred by fuzzy logic sensory analysis and 100% replacement of sugar with mahua flower syrup was acceptable by fuzzy logic sensory analysis.

3.3 Quality ranking of cupcake in general

For the ranking of quality attributes of cupcake in general, similarity values under various scale factors were calculated. Values of membership functions of F1, F2, F3, F4, F5, and F6 as given in Eq. 9 were used in the calculation of similarity values. Now, values of overall membership functions (values of B's) for sensory scores of the quality factors color, flavor, texture, overall acceptability and taste were calculated using the same procedure as described above for the cupcake samples. Using the values of overall membership functions of color (B1), flavor (B2), texture (B3), overall acceptability (B4) and taste (B5) and the values of F1, F2, F3, F4, F5, and F6, the numerators and denominators of Eq. 11 were calculated. Table 6 shows similarity values for all the quality attributes of cupcake.

For comparing the similarity values of cupcake quality attribute we concentrate on the category in which the largest similarity values of respective qualities falls. From Table 6, the largest similarity values of quality attribute OAA (0.9397) and taste (0.8359) were in "highly important" category while the largest similarity values of both flavor (0.9252) and texture (0.8770) were found in the category of "important" and the largest similarity values of quality attribute Color was in "necessary" category. Also, in the same "highly important" category, similarity value for OAA is larger than taste, and in the category of "important", similarity value of texture was found to be less than flavor. Thus out of these five quality attributes, OAA and taste are considered as the first and second most preferable quality respectively, the flavor and texture were considered respectively to be the third and fourth most preferable one and the color as the least preferable deciding factor for the acceptability of cupcake. So the order of preference of quality attributes for the cupcake in general was found to be OAA > Taste > Flavor > Texture > Color. This implies that OAA, taste and flavor are the major quality attributes for a cupcake, which is already reported by many researchers for other foods [17, 25, 26] which emphasizes the importance of this sort of study, where the conclusion cannot be drawn by mere observation. The information obtained in this study can be helpful in the formulation of other mahua products. Finally, we conclude that all the sensory factors are important in general, as the categorization of these factors is ranging from necessary to extremely important.

IV CONCLUSION

Our present study clearly demonstrates that the mahua cupcake (CC15) prepared using mahua flower syrup content 55 g, baking time 14 min, baking temperature 175 ^{0}C was highly acceptable in terms of sensorial characteristics like overall acceptability, color , flavor, taste and texture. The results revealed that as the concentration of mahua flower syrup in cupcake was increased beyond 55 g, texture was found to be hard along with an unsatisfactory aftertaste. In general, the important quality attributes for the cupcake were rated as OAA > Taste > Flavor > Texture > Color. The mahua cupcake would be a healthy substitute of the artificial flavored cupcakes available in the local market. Finally, it was concluded that there is an enormous scope of processed mahua flower products and this study would prove to be a pathway for the further development of processed mahua products. Since there is no information available on fuzzy logic based sensory evaluation of mahua based value added product, this work would provide a platform for further studies on value-added product development from mahua.

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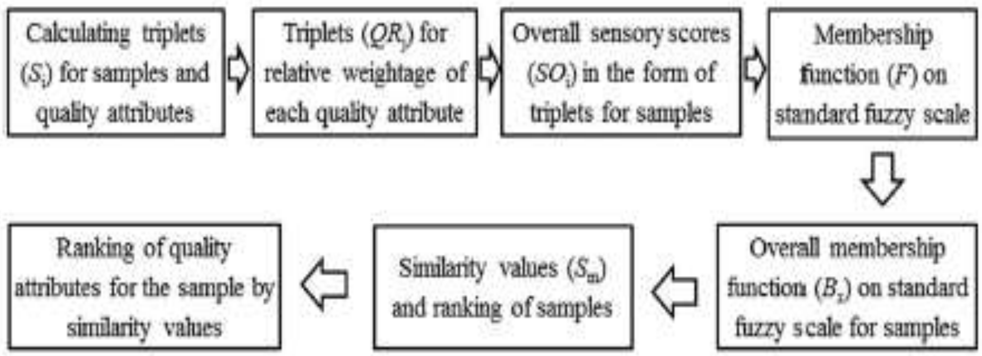

Figure 1. Major step involved in fuzzy modeling of sensory data

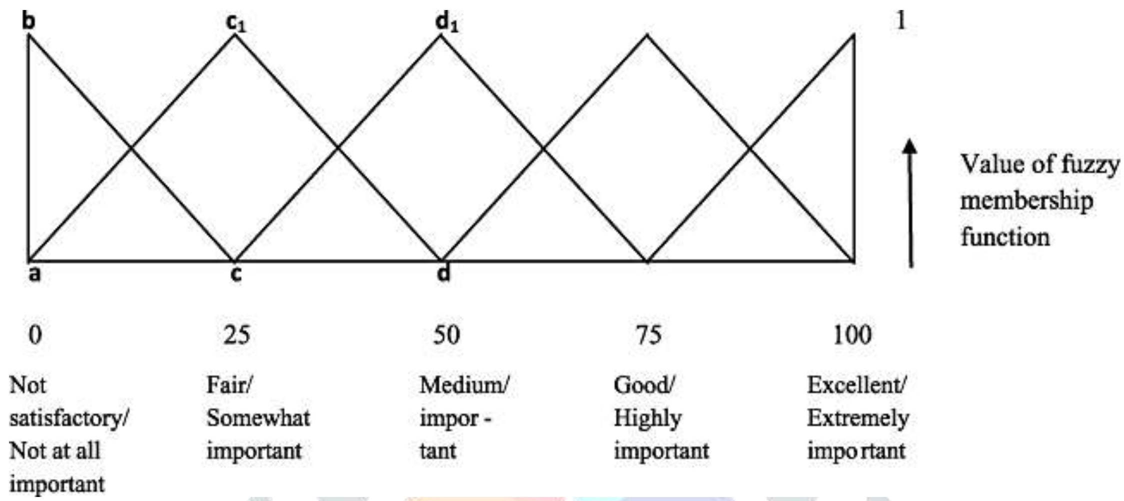

Figure 2. Values of triplets associated with triangular membership distribution function for five points sensory scales

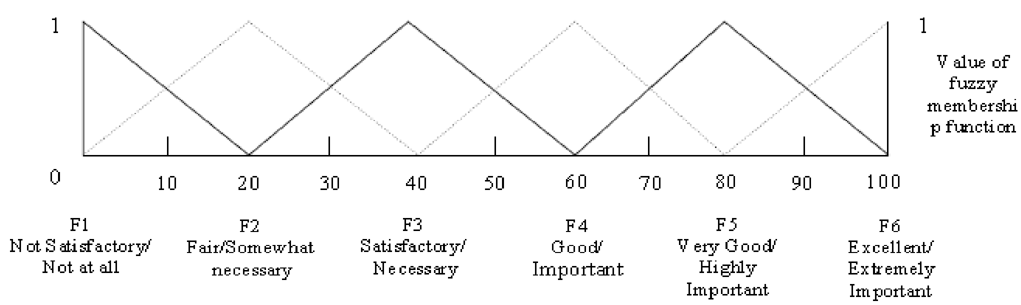

Figure 3. Standard fuzzy scales of six point membership functions (F)

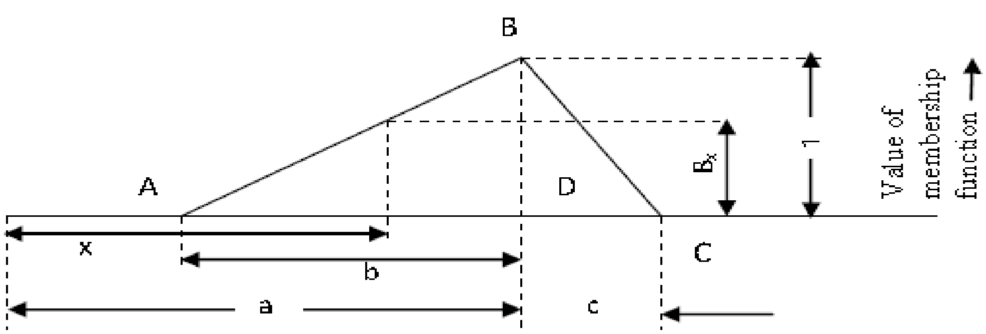

Figure 4. Graphical representation of triplet (a, b, c) and its membership function

Table 1. Triplets associated with sensory scales

Not important/Poor			Somewhat Important/Fair			Important/Medium			Highly Important/ Good			Extremely Important/Excellent		
0	0	25	25	25	25	50	25	25	75	25	25	100	25	0

Table 2. Sum of the number of judges with different preferences and triplets associated with the sensory scores for the quality attributes of cupcake samples

Sensory Quality attributes		Poor	Fair	Medium	Good	Excellent	Triplets for sensory scores		
Color (C)	control	0	0	0	12	3	80	25	20
	CC10	0	1	4	10	0	65	25	25
	CC13	0	1	3	11	0	66.67	25	25
	CC15	0	0	1	13	1	75	25	23.33
	CC9	0	0	3	11	1	71.67	25	23.33
Flavour (F)	control	0	0	0	13	2	78.33	25	21.67
	CC10	0	2	3	10	0	63.33	25	25
	CC13	0	1	2	11	1	70	25	23.33
	CC15	0	0	1	11	3	78.33	25	20
	CC9	0	2	2	11	0	65	25	25
Texture (T)	control	0	0	0	13	2	78.33	25	21.67
	CC10	0	3	1	10	1	65	25	23.33
	CC13	0	2	3	7	0	60.42	25	25
	CC15	0	0	0	12	3	80	25	20
	CC9	0	0	2	12	1	73.33	25	23.33
OAA (O)	control	0	0	0	14	1	76.67	25	23.33
	CC10	0	2	2	10	1	66.67	25	23.33
	CC13	0	0	6	8	1	66.67	25	23.33
	CC15	0	0	1	12	2	76.67	25	21.67
	CC9	0	2	2	11	0	65	25	25
Taste (t)	control	0	0	0	14	1	76.67	25	23.33
	CC10	0	1	3	10	1	68.33	25	23.33
	CC13	0	1	4	10	0	65	25	25
	CC15	0	0	0	13	2	78.33	25	21.67
	CC9	0	4	0	11	0	61.67	25	25

Table 3. Sum of the number of judges with different preferences, triplets associated with scores and the relative weightage for quality attributes of the mahua cupcake samples in general

Quality attributes of the cupcake samples in general	NI	SI	Im	HI	EI	Triplets for sensory scores			Triplets for relative weightage
Color	0	4	8	2	1	50	25	23.33	QCrel= (0.141 0.070 0.066)
Flavour	0	1	5	7	2	66.67	25	21.67	QFrel= (0.188 0.070 0.061)
Texture	0	0	6	7	2	68.33	25	21.67	QTrel = (0.192 0.070 0.061)
OAA	0	0	2	6	7	83.33	25	13.33	QOrel= (0.235 0.070 0.038)
Taste	0	0	1	6	8	86.67	25	11.67	Qtrel = (0.244 0.070 0.033)

EI, extremely important; HI, highly important; Im, important; SI, somewhat important; NI, not at all important; QCrel, triplet for relative weightage of quality attribute color; QFrel, triplet for relative weightage of quality attribute flavor; QTrel, triplet for relative weightage of quality attribute texture; Qtrel, triplet for relative weightage of quality attribute taste;.

Table 4. Values of overall membership function (B) of the five cupcake samples

Overall membership function	Values									
B1	0.0000	0.0000	0.0895	0.2801	0.4707	0.6613	0.8519	1.0000	0.9475	0.7119
B2	0.0000	0.0463	0.2541	0.4620	0.6698	0.8776	1.0000	0.8992	0.6537	0.4082
B3	0.0000	0.0513	0.2589	0.4666	0.6743	0.8820	1.0000	0.8954	0.6531	0.4109
B4	0.0000	0.0000	0.0870	0.2780	0.4691	0.6601	0.8511	1.0000	0.9466	0.7045
B5	0.0000	0.0406	0.2459	0.4512	0.6565	0.8618	1.0000	0.9222	0.6845	0.4468

Table 5. Similarity values of the mahua cupcake and their ranking

Scale Factor	Control	CC10	CC13	CC15	CC9
Not satisfactory, F1	0	0.0059	0.0065	0	0.0051
Fair, F2	0.0592	0.1362	0.1388	0.0586	0.1294
Satisfactory, F3	0.2906	0.4351	0.4369	0.2905	0.4198
Good, F4	0.5802	**0.6824**	**0.6808**	0.5822	**0.6698**
Very good, F5	**0.7043**	0.5785	0.5754	**0.7063**	0.5887
Excellent, F6	0.3059	0.1884	0.1883	0.3053	0.1993
Ranking	II	III	IV	I	V

Table 6 Similarity values and ranking of quality attributes of the mahua cupcake

Scale Factor	Color	Flavor	Texture	OAA	Taste
Not important	0	0	0	0	0
Somewhat Important	0.1822	0	0	0	0
Necessary	**0.8016**	0.2788	0.2327	0	0
Important	0.7801	**0.9252**	**0.8770**	0.3600	0.1467
Highly Important	0.1557	0.6887	0.7303	**0.9397**	**0.8359**
Extremely Important	0	0.0764	0.0893	0.4503	0.5928
Ranking	V	III	IV	I	II

Appendix

Fuzzy Logic score card for evaluation of Cupcake

Product…………………. **Made On……….**

Tested On………

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

Quality attributes		Poor	Fair	Medium	Good	Excellent
Color	control					
	CC10					
	CC13					
	CC15					
	CC9					
Flavour	control					
	CC10					
	CC13					
	CC15					
	CC9					
Texture	control					
	CC10					
	CC13					
	CC15					
	CC9					
OAA	control					
	CC10					
	CC13					
	CC15					
	CC9					
Taste	control					
	CC10					
	CC13					
	CC15					
	CC9					

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

Quality attributes	*Not important*	Somewhat Important	Important	Highly Important	Extremely Important
Color					
Flavour					
Texture					
OAA					
Taste					

Comments if any Signature of the evaluator

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