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Sustainable valorization of amla pomace: optimization of a sweetmeat using the fuzzy logic approach and its quality characterization

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Food waste constitutes nearly half the global waste and is expected to rise due to population growth and changing consumer patterns. Fruit pomace, a prominent by-product of juice production, offers potential nutritional and phytochemical properties that promote improved therapeutic, functional and sensory qualities of food products when incorporated, while supporting sustainable bio-economic practices. Amla pomace, rich in vitamin C and bioactive compounds, has high potential for developing functional foods. Further, utilization of amla pomace in sweetmeats is found to yield better nutritional and functional properties compared to those of traditional khoa based sweetmeats. This study is focused on the development of amla pomace sweetmeats emphasizing on the use of the fuzzy logic approach for optimization of sensory data, considering colour & appearance (CA), body & texture (BT), flavour (F) and overall acceptability (OA) as the sensory quality parameters. The best sweetmeat sample, which performed better than the control samples, consisted of 30% khoa, 22.5% amla pomace, 7.5% desiccated coconut, and 40% sugar. Additionally, the key characteristics that define sweetmeat quality were ranked as follows: OA > BT > F > CA. Further, the nutritional, phytochemical and textural characteristics of control and optimized amla pomace sweetmeat samples were assessed. The amla pomace sweetmeat had significantly higher amounts of fibre (3.97%), ascorbic acid (98.71 mg/100 mL) and phenolic compounds (54.65 mg GAE g^{-1}), while high levels of fat and protein were observed otherwise. Additionally, inclusion of amla pomace enhanced the textural properties of the sweetmeat. Furthermore, the polysaccharides isolated from the amla pomace sweetmeat were analysed for monosaccharide composition using GC-MS and the results illustrated the presence of various monosaccharides including galactose, galacturonic acid, arabinose, rhamnose, glucose, xylose and mannose.

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1 Introduction

Pomace, a residue left over from the extraction of fruit juice, is one of the major by-products of the fruit processing industry. It is known to contain a wealth of nutritional fibre and antioxidant compounds; also, its natural bioactive components provide a variety of therapeutic benefits, including antibacterial, cardio-protective, anti-tumoral, and anti-mutagenic effects.[1] Fruit pomace may also be utilized in a variety of food formulations to manage the textural and rheological behaviour of the product since it has strong techno-functional qualities.[2] Furthermore, in order to build sustainable bio economy-based techniques and convert a linear economy into a circular one, it is imperative that fruit pomace might be valorised.[3] Among, the various fruits available, amla also referred to as Indian Gooseberry (*Emblica officianilis*) is highly valued, due to its richness of polyphenols, phytochemicals, tannins, and minerals. In addition, it contains the highest concentration of vitamin C among any fruit (with the exception of Barbados cherries), ranging from 191 to 720 mg/100 g based on the variety.[4] Besides, amla juice is one of the major value-added products prepared from the amla fruit, which in turn generates ample amount of amla pomace. Amla pomace, like the fruit, contains an appreciable amount of bioactive components in addition to a high amount of dietary fiber,[1] which makes its valorisation even more important. The utilization of this by-product by incorporation into the human food chain, producing novel functional foods with potential uses, would not only benefit the environment but would also expand prospects in the food industry.

Sweets play a significant role in cultural traditions and celebrations while also serving as a source of quick energy, and providing functional health benefits, with burfi, a milk-based Indian sweetmeat, being one of the most popular and nutritious indigenous sweets, traditionally prepared with khoa and sugar in varying proportions.[5] A number of variations of burfi with additional optional ingredients, such as nuts, saffron, fruits, coconut, *etc.*, are also available in the market, however, but the quality and formulation vary widely. Furthermore, sweetmeats have a long shelf life when compared to other milk-

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based sweets, owing to high total solids and low moisture content.[6] Besides, being a milk-based delicacy, it is rich in minerals and protein; nonetheless, it lacks fiber and vitamin C. These nutritional shortcomings might be overcome by integration of vegetables, fruits, dry fruits, and other food ingredients. The synergistic blend of non-dairy and dairy ingredients leads to the development of nutri-dense functional sweetmeats. Various researchers have prepared such sweets, for instance, bottle gourd pomace sweetmeats,[7] virgin coconut meal sweetmeats,[8] bottle gourd burfi,[5] apple pomace burfi,[9] carrot halwa,[10] beetroot and tomato peel powder incorporating burfi,[11] *etc.* Furthermore, in addition to enhancing nutritional properties by adding functional ingredients, it is crucial to study their impact on the sensory properties of prepared foods to develop a clear understanding about their consumer acceptance; hence their sensory analysis is of utmost importance. Sensory analysis refers to a scientific approach to evoke, measure, analyze, and interpret the responses of trained or semi-trained panel members as perceived through touch, taste, sight, sound, and smell of the product.[12] The sensory data obtained, however, is quite subjective and needs to be analysed statistically. In addition, it is not feasible to determine the relative importance of any one sensory attribute in determining whether a food product is accepted or rejected. Thus, to dissipate the degree of ambiguity in human thinking and relating it to a real number, use of fuzzy logic for sensory quality evaluation comes to the rescue.[13]

Fuzzy logic is an influential technique, used for analysing ambiguous and imprecise data and drawing significant conclusions about the acceptance, rejection and rating the qualities of food. The fuzzy set theory transforms the linguistic sensory responses of the judges into numerical values that may be used to compare comparable items. Also, in fuzzy modelling, linguistic variables are used to draw the relationship between independent (like color, aroma, taste, mouthfeel, convenience, *etc.*) and dependent (like acceptance, rejection, ranking, strong and weak features of food) variables.[14] Hence, various researchers have used fuzzy logic for sensory quality evaluation of different products such as aromatic foods packed in starch based films,[15] bread prepared from millet-based composite flours,[16] drinks prepared with yoghurt powder,[17] mango drinks,[18] high pressure processed mango pulp and litchi juice,[13] kokum drinks,[19] probiotic whey beverages,[20] commercial jam samples,[21] and beetroot candy.[22] However no study has been reported on incorporation of nutritionally rich amla pomace into sweetmeats. Therefore, in this study, amla pomace was utilized for the preparation of a novel functional sweetmeat by optimizing the sensory data using fuzzy analysis and its quality parameters were compared with those of the traditional khoa based sweetmeat.

2 Materials and methods

2.1. Procurement of raw materials

Fresh gooseberry (*Embilica officinalis* L. var. Banarasi) fruit, 2 kg, was made available from the farms of Chandra Shekhar Azad Agricultural University, Kanpur, India. Commercial milk, sugar, ghee and desiccated coconut were purchased from a local market in Kanpur, India. All chemicals used were of analytical grade and were procured from Thomas Bakers Pvt. Ltd., India.

2.2. Preparation of khoa

Khoa, the major ingredient for preparation of the sweetmeat, was prepared using commercially available full cream milk (fat: 6%, SNF: 9%) in an open kadhai at a temperature of 80 °C while continuously stirring until a paste like consistency was obtained (TSS 80°B), using a slightly modified method of Tanuja *et al.*, (2017).[9] The final product was spread out, refrigerated in a stainless-steel tray, later packed in air tight containers, and subsequently stored in a refrigerator maintained at 5 ± 1 °C till further use.

2.3. Preparation of amla pomace

Amla fruits (cv. *Banarasi*) of uniform size (38 ± 2 g by weight, fully ripe) were sorted, sanitized using 100 mg L^{-1} sodium hypochlorite solution for 10 min, after which in order to remove the surface moisture, the fruits were spread under fan at ambient conditions of 25 ± 1 °C. The fruits were then deseeded manually and processed in a commercial juicer (Benchtop Equipment, India) to extract the juice. The pomace obtained was then used for further preparation of the sweetmeat.

2.4. Preparation of the amla pomace sweetmeat

Amla pomace, desiccated coconut, khoa, sugar and ghee were the major ingredients used for the preparation of the amla pomace sweetmeat (APS) (Fig. 1). Different samples (S2, S3, S4,

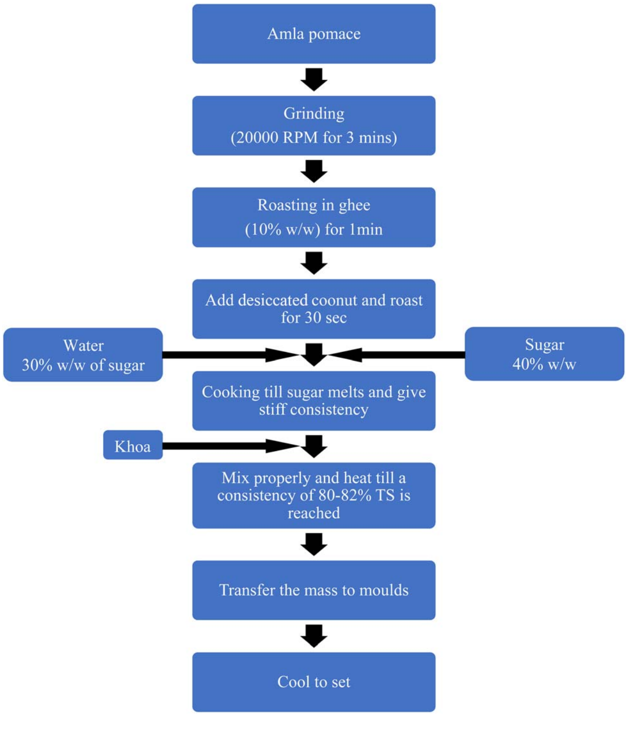

Fig. 1 Flow diagram for the preparation of amla pomace sweetmeat.

Table 1 Formulation used for the preparation of amla pomace sweetmeat

Ingredients (g)	S1	S2	S3	S4	S5	S6
Khoa	60	50	40	30	20	10
Amla pomace	—	7.5	15	22.5	30	37.5
Coconut	—	2.5	5	7.5	10	12.5
Sugar	40	40	40	40	40	40
Total weight	100	100	100	100	100	100

S5 and S6) of APS were prepared by varying the concentrations of khoa, amla pomace, and desiccated coconut, while keeping the sugar content (40% of the mixture) constant (Table 1). The sweetmeat prepared with only khoa and sugar was considered as the control sample (S1). For the preparation of the amla pomace sweetmeat, firstly, fresh amla pomace was ground in a turbo grinder and blender (3000 W, Kent India) for 3 min at 20 000 rpm; it was then roasted at nearly 160 ± 5 °C in ghee (10% of pomace-coconut mixture) for 1 min, followed by addition of desiccated coconut, which was again roasted for 30 seconds and subsequently, sugar and water (@30% sugar) was added. The contents were cooked with continuous stirring on a low flame till the sugar melted at 60 ± 5 °C, post which the calculated amount of khoa was added to the mixture and it was cooked till a consistency of 80–82% total solids was achieved. The hot mixture was then transferred and uniformly spread in silicon moulds with rectangular shapes of 3 × 3 × 1.5 cm^3. It was then allowed to cool at a refrigerated temperature of 6 ± 1 °C for 2 hours, prior to further analysis. The prepared sweetmeat samples are shown in Fig. 2.

2.5. Sensory evaluation

Twelve men and eight women in the age group of 20–50 years from the Department of Food Technology, HBTU Kanpur, made up the panel of sensory judges. Sensory panellists were not smokers or beetle-leaf chewers, and they were chosen based on their good health, average sensitivity, interest in sensory evaluation, ability to focus and familiarity with sweets.[23] After ensuring that they understand the attributes of high-quality sweetmeat as well as the definitions of the various terminologies used in the sensory evaluation, a score sheet comprising the colour & appearance (CA), body & texture (BT), flavour (F) and overall acceptability (OA), as the sensory attributes was created and produced to each panellist to collect their responses. They were advised to rinse their mouth with water before tasting each sample.[18] The panellists were asked to rate the coded samples presented in a random sequence in terms of a five-point linguistic scale of 'not satisfactory', 'fair', 'medium', 'good', and 'excellent'. The panelists were further instructed to mark the preference of each quality attribute of the sweetmeat in terms of being 'not at all important', 'somewhat important', 'important', 'highly important', and 'extremely important', generally. The set of recorded data were analysed using fuzzy comprehensive modelling of sensory scores.[16,17]

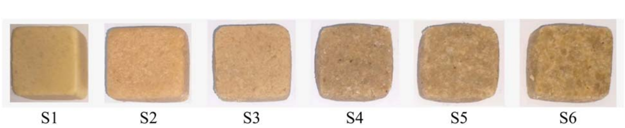

Fig. 2 Sweetmeat samples prepared from amla pomace.

2.6. Fuzzy comprehensive modelling of sensory scores

Fuzzy modelling of sensory scores makes use of linguistic information gleaned from sensory evaluation to rank different sweetmeat samples using the triangular fuzzy membership distribution function.[14] The major steps in the fuzzy modelling of sensory data are as shown in Fig. 3. The first step involves obtaining sensory scores for each sweetmeat sample from panellists and generating triplets using these sensory scores. Herein, a triplet (a, b, c) refers to a set of three numbers used to represent the triangular membership function distribution pattern of sensory scales. These triplets are represented by the three numbers that are displayed in the brackets with the 5-point sensory scales. The distribution pattern of the 5-point sensory scales is made up of the following, "Not satisfactory/Not at all important, (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)" (Fig. 4(a)). Here, the first triplet number 'a' indicates the coordinate of the abscissa where the membership function value is 1, and the second 'b' and third 'c' triplet numbers stand

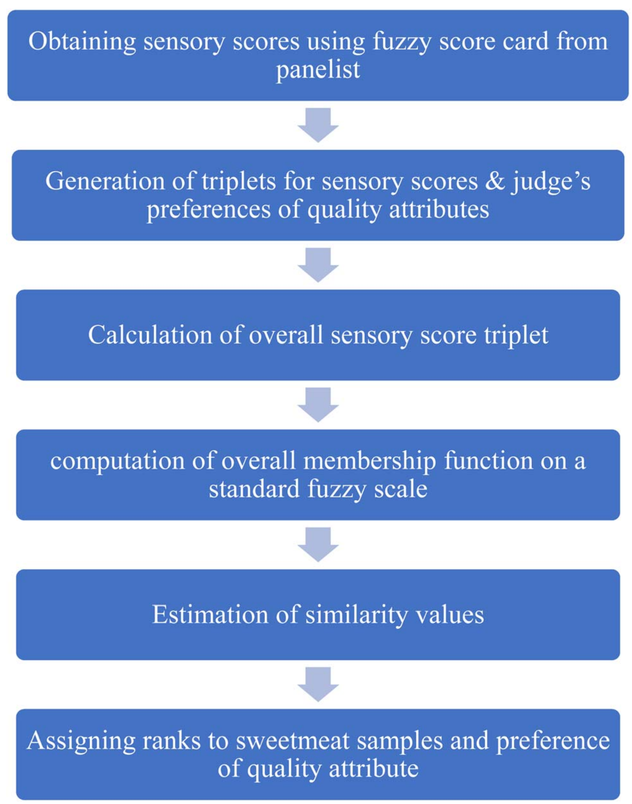

Fig. 3 Representation of steps in fuzzy comprehensive modelling for sensory evaluation.

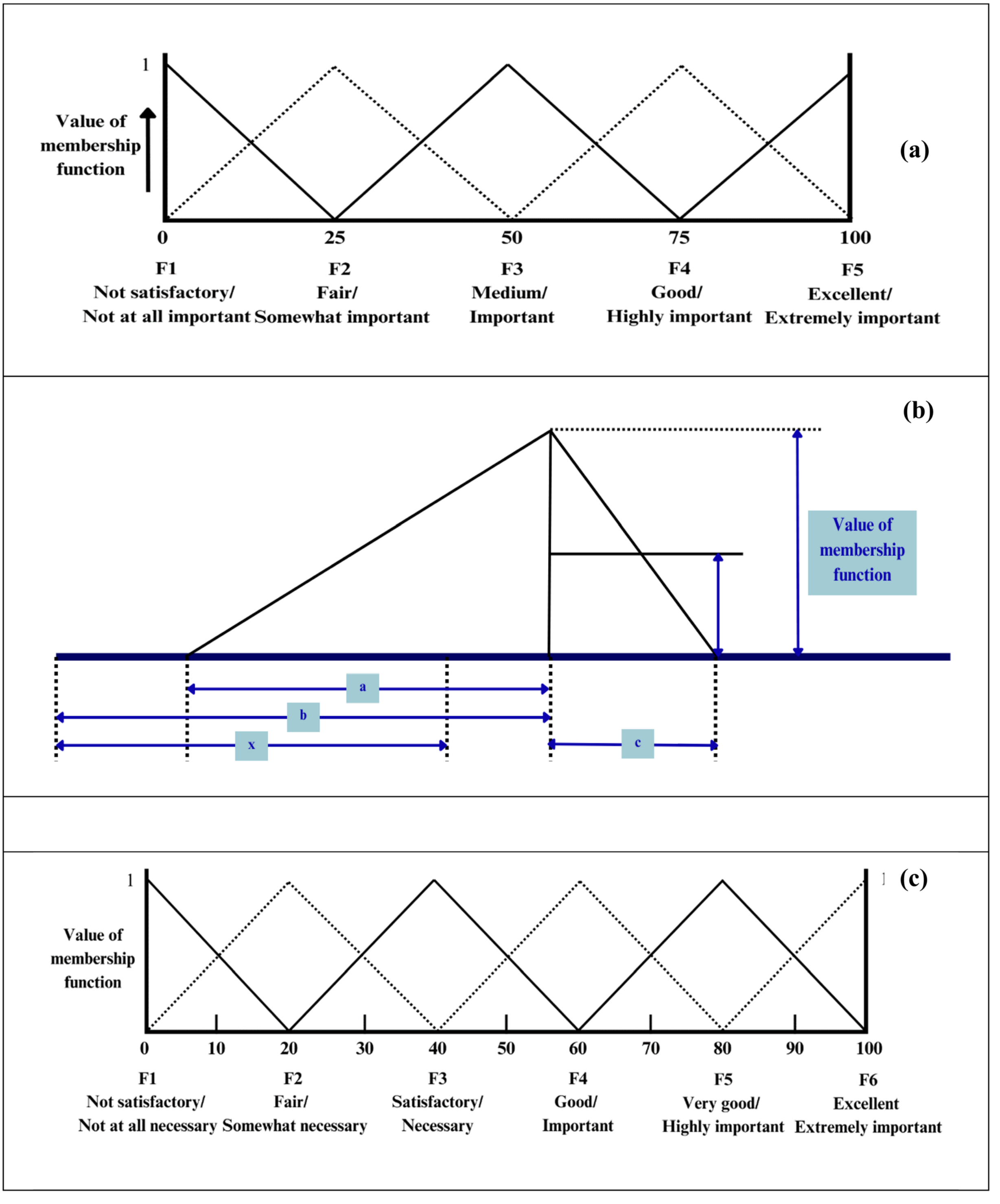

Fig. 4 (a) Representation of the triangular membership function distribution pattern of sensory fuzzy scale, (b) diagrammatic representation of the triplet and its membership function, (c) standard Fuzzy scale.

for the distance to the left and right, respectively, of the first number, where the membership function value is zero (Fig. 4(b)).[17,24]

2.6.1. Estimation of sensory triplet scores for sweetmeat samples and overall quality. A sensory sheet comprising details of samples, sensory attributes, number of judges, and sum of sensory scores is prepared. Triplets associated with the sensory scale were used to calculate the triplets for respective samples (S1, S2, S3, S4, S5, S6) and each quality attribute (CA, BT, F and OA). To determine the **triplets for sensory scores** of different samples, the following equation is used.[18]

$$S_xA = \frac{n_1(0\ \ 0\ \ 25) + n_2(25\ \ 25\ \ 25) + n_3(50\ \ 25\ \ 25) + n_4(75\ \ 25\ \ 25) + n_5(100\ \ 25\ 0)}{n_1 + n_2 + n_3 + n_4 + n_5} \tag{1}$$

Here, x denotes sample number (1 to 6), "A" denotes the quality attribute (CA, BT, F, or OA), and n_1, n_2, n_3, n_4, and n_5 denote the judges' scores corresponding to not satisfactory, fair, medium, good and excellent, respectively, for each sample.

Similarly, **triplets for sensory scores of quality attributes** were also calculated, using the following equation.[18]

$$QA = \frac{p_1(0\ \ 0\ \ 25) + p_2(25\ \ 25\ \ 25) + p_3(50\ \ 25\ \ 25) + p_4(75\ \ 25\ \ 25) + p_5(100\ \ 25\ 0)}{p_1 + p_2 + p_3 + p_4 + p_5} \tag{2}$$

Here, $p_1 + p_2 + p_3 + p_4 + p_5$ denotes the judges' scores corresponding to the importance of each attribute in terms of not at all important, somewhat important, important, highly important, and extremely important, respectively.

Further, the **relative weightage of each attribute (QA_{rel})** was determined by dividing the triplets for sensory scores of the respective quality attribute by a sum of the first digit of the triplet in each attribute, eqn (1), which is subsequently used calculating the **triplet of overall sensory scores** of sweetmeat samples, eqn (3).[18]

$$OS_x = S_xCA \times QCA_{rel} + S_xBT \times QBT_{rel} + S_xF \times QF_{rel} + S_xOA \times QOA_{rel} \tag{3}$$

where the following triplet multiplication rule is applied:[18]

$$(a\ b\ c) \times (d\ e\ f) = (a \times d\ a \times e + b \times d\ a \times f + c \times d) \tag{4}$$

2.6.2. Estimation of the overall membership function. The membership function was calculated using a six-point scale (F_1, F_2, F_3, F_4, F_5, and F_6) with a set of ten numbers each as inputs in a triangular distribution pattern, as shown in Fig. 4(c). It has been used owing to quick convergence of results during fuzzification and defuzzification as well as its ease of interpretation.[17,20] In the triangle distribution pattern, the values of the fuzzy membership function range from a minimum value of 0 to a maximum value of 1, and with reference to Fig. 4(c), the values of membership functions are given by eqn (5).

$$\left.\begin{array}{l} F_1 = (1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0) \\ F_2 = (0.5, 1, 1, 0.5, 0, 0, 0, 0, 0, 0) \\ F_3 = (0, 0, 0.5, 1, 1, 0.5, 0, 0, 0, 0) \\ F_4 = (0, 0, 0, 0, 0.5, 1, 1, 0.5, 0, 0) \\ F_5 = (0, 0, 0, 0, 0, 0, 0.5, 1, 1, 0.5) \\ F_6 = (0, 0, 0, 0, 0, 0, 0, 0, 0.5, 1) \end{array}\right\} \tag{5}$$

where F is the range of membership functions.

Further, the standardized fuzzy scale was linked to the overall quality of the amla pomace sweetmeat and was represented by a triplet, as seen in Fig. 4(b). The scaled membership function value (B_i) is 1 when the abscissa value is a, and is zero if it is greater than $a + c$ or less than $a - b$, and otherwise its value is given by eqn (6).

$$B_i = \begin{cases} \dfrac{i - (a - b)}{b} & (a - b) < i < a \\ \dfrac{(a + c) - i}{c} & a < i < (a + c) \end{cases} \tag{6}$$

The scaled membership values were calculated for $i = (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)$ for the triplet of overall sensory scores of each sweetmeat sample as well as for the triplet of sensory scores of quality attributes in general. The i value for the membership function was given by a set of 10 integers, ranging from $0 < i < 10$ to $90 < i < 100$ with 10 intervals, whereby the maximum values of B_i fell within the specified range.

2.6.3. Estimation of similarity values and ranking of sweetmeat samples. The similarity values (S_m) were computed using standard fuzzy scale (F) and scaled membership function (B) values for each sweetmeat sample and quality attribute, as per eqn (7). These values were collated to determine the maximum values for each sample and quality attribute. The maximum values were then compared and ranked, giving samples/attributes with a higher similarity value a higher rank.

$$S_m(F, B) = \frac{F \times B}{\text{Max }(F \times F \text{ and } B \times B)} \tag{7}$$

Here, $F \times B$ is the product of F with the transpose of B, $F \times F$ is the product of F with the transpose of F, and $B \times B$ is the product of B with the transpose of B, calculated using the rule of matrix multiplication.[17]

2.7. Quality evaluation of the sweetmeats

2.7.1. Nutritional quality. The sweetmeat samples were tested for moisture, protein, fat, fibre and ash content as per the AOAC.[25] Furthermore, the total carbohydrate content (%) was calculated by subtracting all the previously mentioned values from 100.

2.7.2. Phytochemical quality. The ascorbic acid content of the sweetmeat samples was ascertained, using the 2,4-dichlorophenol-indophenol dye technique as reported by Kaur *et al.*[26] Meanwhile, the Folin–Ciocalteu colorimetric method was used to determine the total phenolic content as described by Prasad *et al.*,[27] with certain modifications. Briefly, 1.0 g of the sample was mixed thoroughly in 25 mL of methanol for 2 h at 200 rpm in a vortex shaker (Orbitek Sciegenics Biotech, India), followed by filtration through muslin cloth and centrifugation at 10 000 rpm for 15 minutes. The supernatant thus obtained was collected and used for the analysis. TPC was determined by mixing 1 mL of supernatant with 0.5 mL of Folin–Ciocalteu reagent and 7 mL distilled water in the test tube, which was left for 5 min at room temperature, followed by addition of 1.5 mL of (20% w/v) sodium carbonate and subsequent mixing in a vortex shaker. The test tube with the reaction mixture was left in the dark for 2 h at room temperature, and its absorbance was measured at 760 nm with a spectrophotometer, using methanol as blank. The results were then calculated by using the equation of the standard curve absorbance *versus* concentration of a standard compound, gallic acid, and therefore, the values were represented as gallic acid equivalents (mg GAE/100 g).

2.7.3. Textural quality. A TAXT2 texture analyzer (Stable Micro system, England) with a 5 kg load cell was used to examine the textural quality. A single sweetmeat piece ($3 \times 3 \times 1.5\ cm^3$) was compressed with a P-75 probe at a test speed of $1.0\ mm\ s^{-1}$ to 50% of its initial height. The post-test speed was set at $0.5\ mm\ s^{-1}$, while the initial pre-test and post-test speeds were limited at $1\ mm\ s^{-1}$, with a 5 s time lapse between two compression cycles. Hardness, cohesiveness, chewiness, gumminess, springiness, and adhesiveness were ascertained using the acquired TPC (texture profile curve) force–time curve.[28]

2.7.4. Monosaccharide profiling of polysaccharide fractions extracted from the sweetmeats. Polysaccharide extraction from sweetmeat was performed following the method outlined by Cheng *et al.*,[29] with slight modifications. Sweetmeat was dried and crushed to make powder. The powder was then mixed with hot distilled water at a 1 : 20 ratio and stirred for 5 hours before being filtered. This process was repeated twice. The polysaccharide extract was precipitated by adding absolute alcohol in a fivefold volume and the resulting precipitate was then collected through centrifugation and subsequently freeze-drying. Further, in order to isolate the polysaccharide fractions, the extracted polysaccharides were re-dissolved in deionized water, diluted to 5% (w/v), treated with Sevage reagent and dialyzed using a membrane with a molecular cut-off of 5000 (MWCO5000, Sigma Aldrich USA). Again, the crude polysaccharides were isolated by adding five times the volume of absolute alcohol followed by centrifugation and freeze drying. Further, the crude polysaccharide, 200 mg, was purified using a Sepharose CL-6B column (dimensions: 3.5 × 90 cm; GE Healthcare Bio-Sciences, Pittsburgh, USA). Elution was carried out using 100 mM NaCl solution at a flow rate of $0.5\ mL\ min^{-1}$ to attain homogeneity.

Subsequently, the monosaccharide profile of the resulting purified polysaccharide fractions was determined using gas chromatography-mass spectrometry (GC-MS), following the Blumenkrantz and Asboe–Hansen method for determination of uronic acid.[30] To enable the simultaneous detection of aldoses and uronic acids, equimolar ($2\ mol\ L^{-1}$) monosaccharide standards were mixed with 1 mL of $0.1\ mol\ L^{-1}$ sodium carbonate solution and 1 mg of inositol in an ampoule. The mixture was neutralized with 25% acetic acid. Desalting was performed for 2 hours using a cation exchange resin, followed by rinsing with 5 mL of distilled water and filtration through quantitative filter paper to collect the supernatant. The supernatant was concentrated under reduced pressure, then dried after the addition of 3 mL methanol. This methanol treatment was repeated five times to eliminate borate. Aldonic acids in the monosaccharides were converted to lactones by vacuum heating at 85 °C for 2 hours. The residue was then dissolved in 1 mL of anhydrous pyridine and 1 mL of *n*-propylamine, followed by heating at 55 °C for 30 minutes. Afterward, the reaction mixture was dried at 45 °C under reduced pressure. To derivatize the residue, 0.5 mL each of anhydrous pyridine and acetic anhydride was added, and then heated at 95 °C for 1 hour. The solution was then concentrated and dried. The resulting residue was dissolved in 1 mL of anhydrous chloroform, centrifuged, and the supernatant was used for GC-MS analysis using a TRACE GC-POLARISQ system (Thermo Fisher Scientific, USA).

Furthermore, for the actual sample analysis, 5 mg of the polysaccharide fraction was hydrolyzed by dissolving it in 2 mL of $2\ mol\ L^{-1}$ trifluoroacetic acid in an ampoule. The ampoule was purged with nitrogen and sealed, then heated at 110 °C for 2 hours. The hydrolysate was dried under reduced pressure at temperatures below 40 °C. To remove residual trifluoroacetic acid, 3 mL of methanol was added and evaporated, repeating this process five times. Finally, the hydrolysate was reduced and acetylated following the same procedure as above. The final residue was dissolved in 5 mL of anhydrous chloroform and analyzed *via* GC-MS.

2.8. Statistical analysis

All experiments were performed in triplicate and data were statistically analysed with SPSS software version 27.0 (IBM Corporation, New York, USA). The difference in the means was determined using Tukey's test at $p < 0.05$ by one way analysis of variance (ANOVA).

3 Results and discussion

3.1. Fuzzy analysis of the sensory data of sweetmeats

The sensory scores for each sweetmeat sample given by the panellists were summarized and analysed by using fuzzy logic comprehensive modelling as adopted by Das (2005).[14]

3.1.1. Triplets associated with the sensory scores and quality attributes of sweetmeat samples. The sensory scores for different sweetmeat samples given by the panellists are shown in Table 2. These responses are observed to be quite broad ranging, implied by the varying preference levels of the judges

Table 2 Sum of sensory scores and triplets associated with it for the quality attributes of amla pomace sweetmeat samples

Samples	Not satisfactory	Fair	Medium	Good	Excellent	Triplets for sensory scores			
Colour and appearance (CA)									
S1	0	3	6	11	0	S_1CA	60.00	25.00	21.25
S2	0	0	5	12	3	S_2CA	72.50	25.00	21.25
S3	0	3	6	10	1	S_3CA	61.25	25.00	35.25
S4	0	0	2	9	9	S_4CA	83.75	25.00	13.75
S5	1	10	8	1	0	S_5CA	36.25	23.75	25.00
S6	1	5	12	1	1	S_6CA	45.00	23.75	23.75
Body and texture (BT)									
S1	0	2	8	9	1	S_1BT	101.25	25.00	23.75
S2	0	4	6	9	1	S_2BT	58.75	25.00	23.75
S3	1	2	4	9	4	S_3BT	66.25	23.75	18.75
S4	0	1	9	8	2	S_4BT	63.75	25.00	22.50
S5	1	8	10	1	0	S_5BT	38.75	23.75	25.00
S6	0	6	11	3	0	S_6BT	46.25	25.00	25.00
Flavour (F)									
S1	0	2	11	6	1	S_1F	56.25	25.00	23.75
S2	0	3	4	9	4	S_2F	72.50	25.00	20.00
S3	1	5	5	7	2	S_3F	55.00	23.75	22.50
S4	0	1	1	12	6	S_4F	78.75	25.00	17.50
S5	2	10	7	1	0	S_5F	33.75	22.50	25.00
S6	2	9	6	3	0	S_6F	37.50	22.50	25.00
Overall acceptability (OA)									
S1	0	1	9	10	1	S_1OA	66.25	26.25	25.00
S2	0	2	5	13	0	S_2OA	63.75	25.00	25.00
S3	0	5	5	9	1	S_3OA	57.50	25.00	23.75
S4	0	1	5	9	5	S_4OA	72.50	25.00	18.75
S5	3	8	7	2	0	S_5OA	35.00	21.25	25.00
S6	3	5	10	2	0	S_6OA	38.75	21.25	25.00

for the various quality attributes of the sweetmeat samples. The corresponding triplets for the sensory scores given by the panel members were calculated using a triangular membership function following eqn (1) and are represented in Table 2. A triplet for the corresponding sample and quality attribute might be obtained using the sum of sensory scores, triplet associated with the sensory score and number of judges. For sample 1, its colour & appearance, value of triplet, and S_1CA are denoted as eqn (8).

$$S_1CA = \frac{0(0\ \ 0\ \ 25) + 3(25\ \ 25\ \ 25) + 6(50\ \ 25\ \ 25) + 11(75\ \ 25\ \ 25) + 0(100\ \ 25\ \ 0)}{0 + 3 + 6 + 11 + 0} = (60.00\ \ 25.00\ \ 21.25) \tag{8}$$

where the numbers 0, 3, 6, 11, and 0 in the numerator denote the number of judges who rated the colour & appearance of sample 1 as not satisfactory, fair, medium, good and excellent, respectively, while the numbers in parentheses represent the distribution pattern of the 5-point standard sensory scales (Fig. 4(a)). The denominator, on the other hand, denotes the total number of judges. These triplets are the values of colour & appearance, body & texture, flavour, and overall acceptability of various sweetmeat samples on the sensory scale that ascertained the numerical positions of the quality criteria on them. Likewise, the triplets for sensory scores of quality attributes (CA, BT, F & OA) were calculated using the priority grades given by the panel members illustrated in Table 3. Most of the judges gave preference of "highly important" and "extremely important" for all the quality attributes. However, flavour and overall acceptability seemed to be the most influential attribute as 12 and 8 judges out of 20 graded it as "extremely important", respectively, which would be confirmed once the similarity values for the quality attributes of various sweetmeat samples have been calculated. Furthermore, triplets for the relative weightage of quality attributes were also calculated (Table 3), which facilitated calculation for the triplets for the overall sensory scores for the samples using eqn (3). The overall sensory scores for the sweetmeat samples have been presented in eqn (9):

Table 3 Sum of sensory scores for quality attributes and triplets associated with it for the amla pomace sweetmeat samples

Quality attribute	Not at all important	Somewhat important	Important	Highly important	Extremely important	Triplets for sensory scores				Triplets for relative weightage			
CA	0	2	6	9	3	QCA	66.25	25.00	18.75	QCA_{rel}	0.211	0.079	0.059
BT	0	0	5	9	6	QBT	76.25	25.00	17.50	QBT_{rel}	0.243	0.079	0.055
F	0	0	1	7	12	QF	88.75	25.00	10.00	QF_{rel}	0.283	0.079	0.032
OA	0	0	2	10	8	QOA	82.50	25.00	15.00	QOA_{rel}	0.263	0.079	0.048

$$\left.\begin{array}{l} \mathrm{OS}_1 = (70.608, 45.015, 37.744) \\ \mathrm{OS}_2 = (66.858, 46.315, 35.458) \\ \mathrm{OS}_3 = (59.711, 43.466, 36.467) \\ \mathrm{OS}_4 = (74.517, 48.805, 32.789) \\ \mathrm{OS}_5 = (35.822, 34.193, 34.651) \\ \mathrm{OS}_6 = (41.539, 36.389, 33.053) \end{array}\right\} \tag{9}$$

3.1.2. Overall membership functions on a standard fuzzy scale. The six-point sensory scale (F_1, F_2, F_3, F_4, F_5, and F_6) was employed for assessing the previously mentioned sensory scores, and the values of the overall membership function of the samples' sensory scores on the standard fuzzy scale, B_i, were calculated as per eqn (6). For instance, the overall sensory score of sample 1 was calculated to be (70.608, 45.015, 37.744), depicting the values of a, b and c to be 70.608, 45.015, and 37.744, respectively, which was further used to calculate the values of B at $i = 0$, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100. Consequently, B1 was found to be (0, 0, 0.0979, 0.3201, 0.5422, 0.7643, 0.9865, 1.0000, 0.7512, 0.4886). Similarly, the overall membership functions for S2, S3, S4, S5 and S6 were also calculated, and are demonstrated as eqn (10):

$$\left.\begin{array}{l} \mathrm{B1} = (0.0000, 0.0000, 0.0979, 0.3200, 0.5422, 0.7643, 0.9865, 1.0000, 0.7512, 0.4886) \\ \mathrm{B2} = (0.0000, 0.0000, 0.2042, 0.4201, 0.6360, 0.8519, 1.0000, 0.9114, 0.6294, 0.3473) \\ \mathrm{B3} = (0.0000, 0.0864, 0.3165, 0.5465, 0.7766, 1.0000, 0.9921, 0.7179, 0.4436, 0.1694) \\ \mathrm{B4} = (0.0000, 0.0000, 0.0879, 0.2928, 0.4977, 0.7026, 0.9074, 1.0000, 0.8328, 0.5278) \\ \mathrm{B5} = (0.2488, 0.5373, 0.8297, 1.0000, 0.8794, 0.5908, 0.3022, 0.0137, 0.0000, 0.0000) \\ \mathrm{B6} = (0.1333, 0.4081, 0.6829, 1.2407, 1.0000, 0.7440, 0.4415, 0.1389, 0.0000, 0.0000) \end{array}\right\} \tag{10}$$

3.1.3. Similarity analysis and ranking of the sweetmeat samples. The similarity values for the sweetmeat samples were determined by employing eqn (7). These similarity values for all six samples, in terms of 'not satisfactory', 'fair', 'satisfactory', 'good', 'very good' and 'excellent' scale factors, are presented in Table 4. For sample S1, the highest similarity value of 0.6696 was observed to lie in the 'good' category, similar to S2 and S3, recording 0.7104 and 0.7335 similarity values, respectively. Besides, in case of S4 the highest similarity value (0.7025) was observed to lie in the 'very good' category, while for S5 and S6, values 0.7961 and 0.7464, respectively were the highest, falling under the 'satisfactory' category. On comparison of these similarity values S4 was assigned rank 1, followed by S3, S2, S1, S5 and S6. Thus, it could be concluded that sample S4 comprising 30% khoa, 22.5% amla pomace, 7.5% desiccated coconut, and 40% sugar was found to be the best ranked sweetmeat sample among the control and amla pomace sweetmeat samples. This trend in similarity values for sensory scores may be justified by the similar trend in terms of CA, BT, F and OA, solitarily, among the various sweetmeat samples given in Table 1, wherein most panel members considered S4 as Excellent/Good, with respect to quality attributes, while S1, S2 and S3 samples were largely considered as Good, unlike for samples S5 and S6 that were mostly labelled as Medium/Fair.

The incorporation of amla pomace to the sweetmeat resulted an increase in the ranking of the samples with respect to colour and appearance (CA) for samples S1, S2, S3 and S4, as the light green colour of the sweetmeat appeared more enthralling with the increasing levels of pomace; however, for the S5 and S6 samples with 20 and 10% khoa in combination with pomace and desiccated coconut, the darker green colour of the sweetmeat made it less acceptable. A comparable finding has been documented regarding sweetmeat made with bottle gourd pomace.[7] The study reported replacing 10, 20, 30 and 40% of khoa-sugar sweetmeat with bottle guard pomace, with sweetmeat samples having 30% of pomace garnering the highest scores for appearance. Furthermore, the scores for body and texture (BT) increased up to 30% pomace & desiccated coconut, as their incorporation adds the desired level of hardness to the sweetmeat samples, imparted by the fibre present in them. However, samples with the replacement of khoa beyond 30%

Table 4 Similarity values of amla pomace sweetmeat samples

Scale factors	S1	S2	S3	S4	S5	S6
Not satisfactory	0.0000	0.0000	0.0116	0.0000	0.1591	0.0852
Fair	0.0685	0.1121	0.1811	0.0645	0.6122	0.4492
Satisfactory	0.3434	0.4286	0.5305	0.3266	**0.7961**	**0.7464**
Good	**0.6696**	**0.7104**	**0.7335**	0.6498	0.4118	0.4434
Very good	0.6608	0.5992	0.4665	**0.7025**	0.0507	0.0909
Excellent	0.2294	0.1791	0.1048	0.2601	0.0000	0.0000

had significantly increased hardness that was not preferred by the panellists, resulting from the greater percentage of bulking agent consisting of fibre. Similar observations have been reported in case of bottle guard pomace sweetmeat, in which samples with 30% pomace recorded the best scores for body and texture.[7] Besides, another study on incorporation of apple pomace in khoa burfi reported that experimental samples with 15% pomace received the highest scores for the texture of burfi.[9] Besides, the flavour (F) in sweetmeat samples also increased with the pomace percentage, when compared to the control, owing to the improved sour and tangy flavour imparted by amla pomace. However, the reverse trend was observed upon further increase in khoa replacement, due to the prominent amla flavour. A similar observation has been recorded in apple pomace burfi and kinnow burfi,[9,28] wherein the sensory scores for flavour increased with increase in percentage of the flavouring component in the burfi samples. Further, burfi samples blended with different levels of guava pulp (0 to 20%) showed rising scores for flavour up to 10% pulp.[31] Also, a similar trend was recorded in case of OA scores for the amla pomace sweetmeat samples. This might be attributed to the combined influence of colour, texture and flavour, recorded in terms of CA, BT and F, which collectively impact the overall acceptability of the product. Therefore, a synonymous pattern as observed in case of these quality attributes is expected in case of OA across the experimental samples. Hence, cumulatively S4 was rated the best sample as denoted by its similarity value. Aligned observations were made in case of khoa burfi with incorporated orange rind,[32] guava pulp,[31] and bottle guard pomace sweetmeat.[7]

3.1.4. Quality ranking of the sweetmeat samples. Different quality features are significant for different types of food in terms of popularity. Colour and appearance are key to consumer appeal and market value, especially in case of milk based sweets.[28] Further, the body and texture of the sweetmeat are other critical factors that affect its sensorial properties and play a major role in its acceptability.[33] The textural attributes of milk based sweets are generally discussed in terms of their hardness, which is prominently affected by the moisture content, as lower moisture content corresponds to a harder and less desirable texture of the sweetmeat.[34] Besides, in case of pomace incorporating sweetmeats the fibre fractions also affect the hardness inevitably with a higher proportion of fibre resulting in increased hardness, which again beyond a certain level makes the produced sweetmeat undesirable.[7,9] The flavour of the sweetmeat, apart from the above quality parameters, is another attribute that deeply affects its likability. Further, adding a flavoured ingredient to the traditional khoa based sweetmeat enhances its sensory appeal, thereby increasing consumer acceptance. Numerous studies support this idea, as they recommend addition of fruit waste or fruit pulp as flavouring and functional ingredients to the traditional sweets.[9,28,31,32,35] Moreover, these studies have reported better acceptability of flavoured sweets in terms of flavour sensory scores, when compared to traditional sweets considered as control samples. Besides, the general perception related to the acceptance and palatability of the sweetmeat can be expressed in terms of its overall acceptability. Thus, colour & appearance (CA), body & texture (BT), flavour (F), and overall acceptability (OA) were selected as quality attributes for amla pomace sweetmeat.

To determine the significant element, these general quality attributes of the sweetmeat were ranked, followed by the estimation of similarity values under various scale factors. The values of the overall membership functions for the sensory scores of these attributes were determined by applying the same method as previously described, followed by the determination of associated similarity values. Table 5 shows the similarity for all the quality attributes of the sweetmeat samples. By comparing the similarity values, OA (0.9600) was found to be "highly important". This is because OA might be considered as composite and being collectively influenced by colour, texture and flavour of the product. Further, acceptance of individual quality attributes is possibly subjective; however, their collated preferences are likely to be unified. Thus, OA was considered to be the most influential attribute for sweetmeat.

Besides, BT and F were also "highly important"; however, the similarity values for BT (0.9071) were higher than that of F (0.8850). The body and texture of any food product have a deep impact on consumers' perception about its acceptance; in particular, they impact the desirability for milk-based sweets, such as sweetmeat. The texture of milk-based sweets was evaluated on the basis of their hardness which might not be too soft nor too hard, in order to appeal to the masses. Thus, BT is one of the key attributes of sweetmeat samples, similar to flavour. Flavour addition to traditional khoa based sweetmeats would definitely impart an upper hand, as it adds versatility to them. Hence, BT and F were ranked as the second and third most important factors, respectively, although the similarity values for both were quite close. Furthermore, CA was assigned the "important" tag, making it not as important an attribute as the other quality attributes being considered in the study, nonetheless still being prominently advocated by the associated high

Table 5 Similarity values of quality attributes of sweetmeats

Scale factors	CA	BT	F	OA
Not at all necessary	0.0000	0.0000	0.0000	0.0000
Somewhat necessary	0.0000	0.0000	0.0000	0.0000
Necessary	0.2900	0.0700	0.0000	0.0200
Important	**0.9300**	0.6400	0.2300	0.4200
Highly important	0.6267	**0.9071**	**0.8850**	**0.9600**
Extremely important	0.0557	0.2586	0.6109	0.4310

similarity value (0.9300). This might be attributed to the effect of colour and appearance on the initial appeal of the food product; nonetheless, its texture and flavour directly affect the eating experience, thus, latter attributes would ultimately determine the overall acceptability and enjoyment of the product.[34] Hence, the general order of preference for the sweetmeats' quality criteria was OA > BT > F > CA. These results reflect the general significance of all quality attributes, seconded by the fact that these attributes are categorized from being important to highly important. Further, the relative order of the significance of these characteristic attributes in determining the acceptability has been found to vary from product to product[36] thereby, this finding highlights the significance of conducting studies of this kind, where conclusions cannot be

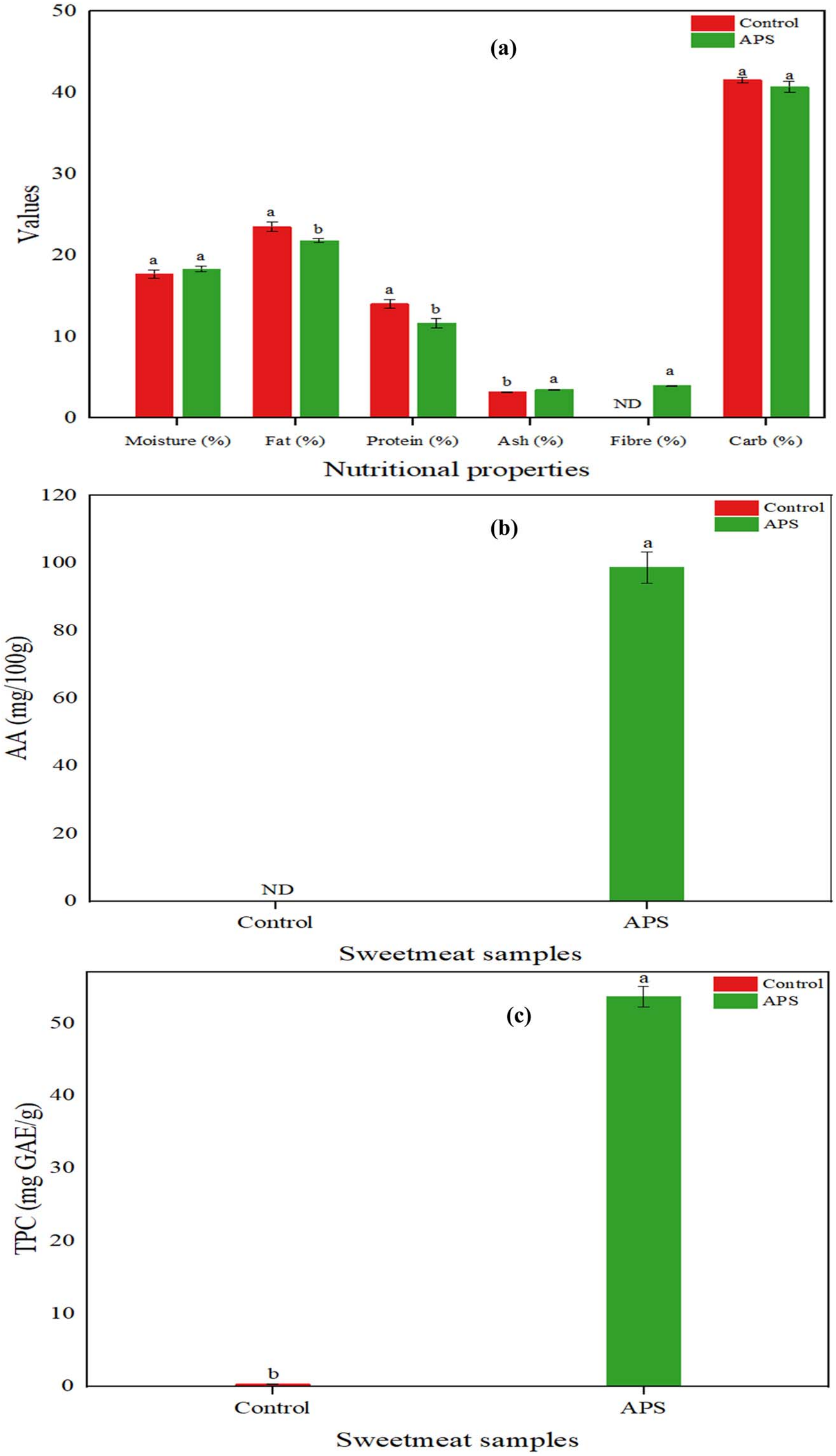

Fig. 5 Nutritional and phytochemical quality of amla pomace sweetmeat (APS): (a) nutritional properties, (b) ascorbic acid content, (c) total phenolic content. Different letters on the bars show the significant difference in the sweetmeat samples ($p \leq 0.05$).

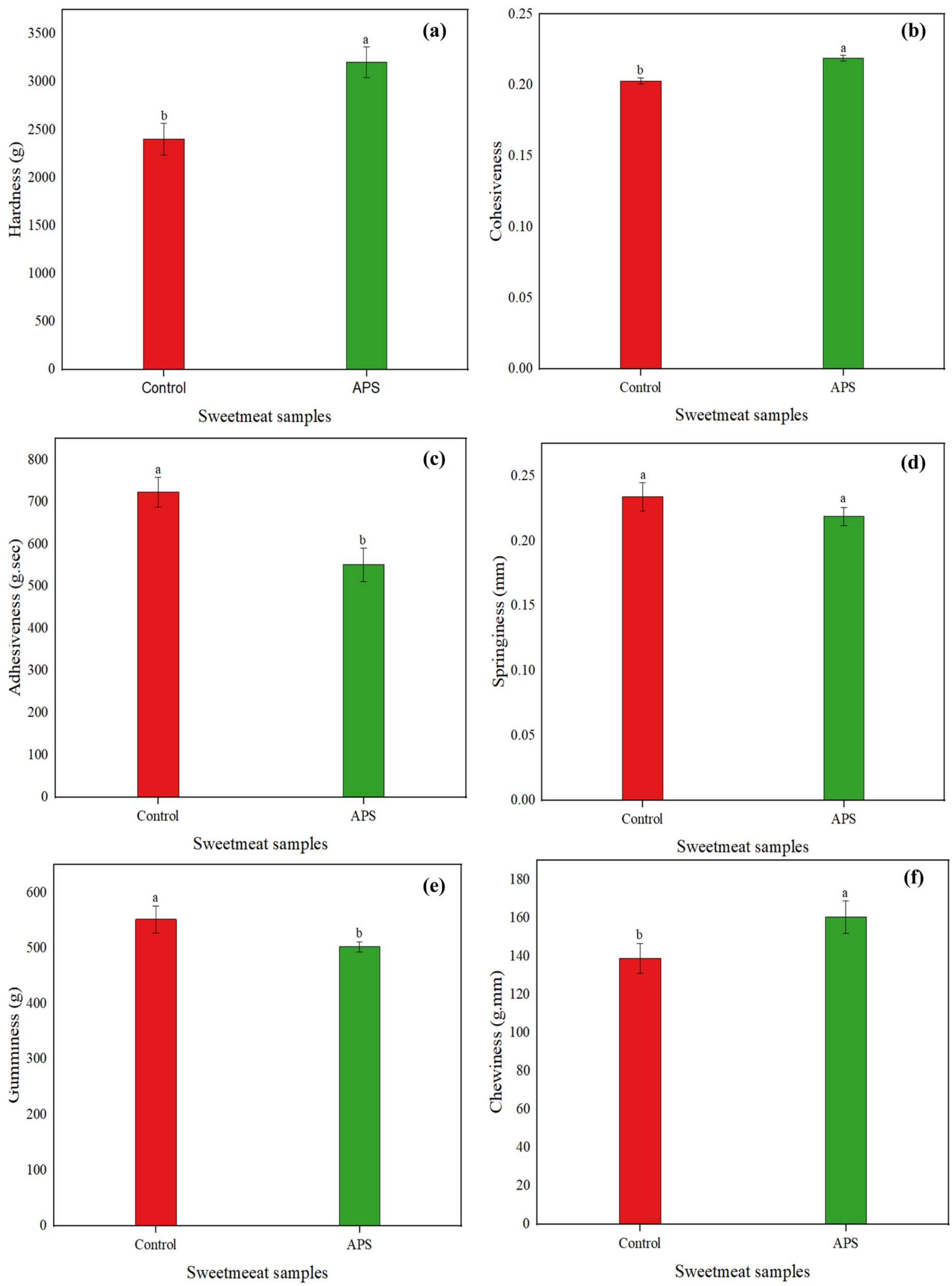

Fig. 6 Textural quality of amla pomace sweetmeat (APS): (a) hardness, (b) cohesiveness, (c) adhesiveness, (d) springiness, (e) gumminess, (f) chewiness. Different letters on the bars show the significant difference in the sweetmeat samples ($p \leq 0.05$).

drawn from observations alone. In addition, similar products can also benefit from the information gathered in this study.

3.2. Quality of amla pomace sweetmeats

3.2.1. Nutritional quality. The proximate composition of the control and the best amla pomace sweetmeat (S4) samples is shown in Fig. 5(a). The moisture content in both samples did not differ significantly ($p > 0.05$), with the control sample containing 17.67% moisture and the pomace sweetmeat containing 18.33% moisture. The slight increase in moisture content in the pomace sweetmeat may be attributed to the moisture present in the fresh pomace, which was incorporated after being roasted in ghee for a few minutes during the sweetmeat preparation. Further, the fat and protein percentages in the control sweetmeat sample (23.52% & 14.06%, respectively) were found to be higher than those of the APS sample (21.81% & 11.69%, respectively). Khoa (30%) and the desiccated coconut (7.5%) are the major sources of fat and protein in amla pomace sweetmeat, having 22.5% amla pomace that comprises a negligible amount of these nutrients.[1] The ash content was higher in case of amla pomace sweetmeat samples, while a slightly higher carbohydrate percentage was observed in the control. Besides, it was observed that the addition of amla pomace resulted in an increase in the fibre content in the sweetmeat samples (3.97%) owing to the fact that the milk solids and sugar present in the control sweetmeat do not contain fibre and the amla pomace (having nearly 17.85% fibre) along with the desiccated coconut (having nearly 6.7% fibre) acted as the major contributors, as reported by Muzaffar *et al.*[1] and USDA, respectively.[37] Similar findings pertaining to a decrease in protein and fat content along with the increase in fibre content have been reported in case of sweetmeat samples incorporating bottle guard pomace, apple pomace and walnut powder.[5,7,9,38]

3.2.2. Phytochemical quality. The phytochemical properties of the sweetmeat samples are presented in Fig. 5(b) and (c). The control sweetmeat did not have any ascorbic acid content, which may be attributed to the absence of ascorbic acid content in its constituents, khoa and sugar. However, in case of amla pomace sweetmeat (98.71 mg/100 g), amla pomace served as the major contributor of ascorbic acid owing to the ample amount of ascorbic acid present in it.[1] Besides, a significant amount of total phenolic content was observed in case of amla sweetmeat samples (54.65 mg GAE g^{-1}) when compared to the control (0.32 mg GAE g^{-1}). This may be attributed to the presence of enough total phenol in amla pomace.[1] Additionally, it was noted that although khoa for the control burfi formulation did not contain any phenolic substrate as in case of amla pomace sweetmeat, still it did exhibit some antioxidative activity, although very slight, as depicted by 0.32 mg GAE g^{-1} total phenolic content. This might be due to the formation of Maillard browning products and free sulphur hydroxide groups during the thermal desiccation of milk, as these maillard reaction products are reported to have the potential to react with the Folin-Ciocalteau reagent and contribute to TPC.[39] Similar observations have been reported in control burfi samples prepared by Prasad *et al.*[27]

3.2.3. Textural quality. The textural attributes of sweetmeats are crucial in determining their palatability. Complex food preparation and processing parameters such as its composition, processing, packaging and storage all influence the texture of the food. In dairy products particularly, textural properties are often assessed based on firmness, which is negatively impacted by the moisture content. In this study, sweetmeat sample with incorporated amla pomace had significantly higher firmness as compared to the control, with observed hardness values of 3203.6 and 2402.6 g respectively (Fig. 6). This is attributed primarily to the addition of bulking agents, fundamentally composed of the fibre content imparted by the pomace. Synonymous inflation in firmness values has been reported in case of sweetmeat samples with incorporated bottle guard pomace and apple pomace, when compared to the control.[7,9] Furthermore, cohesiveness was also found to be higher in case of amla pomace sweetmeat (0.219), in comparison to the control (0.203).

Besides, the adhesiveness of the sweetmeat is correlated to its stickiness, attributed to the presence of mainly protein and fat. Control samples had comparatively higher adhesiveness (723.6 g s), as replacing 30% khoa with amla pomace negatively affects the adhesiveness (551.1 g.sec) in case of amla pomace sweetmeat. This might be attributed to the negligible amount of fat and protein present in the amla pomace.[1] A synonymous trend was observed in case of springiness and gumminess of the sweetmeat samples. Fat is the major contributor to springiness of the food commodity, and the replacement of fat-rich khoa with fibre rich pomace with lower fat content results in a lower springiness value in the amla pomace sweetmeat (0.219 mm) when compared to the control sweetmeat (0.234 mm). Also, higher gumminess was found in the latter (551.6 g) when contrasted with the former sweetmeat sample (502.5 g). On the other hand, the fibre content in pomace was observed to have

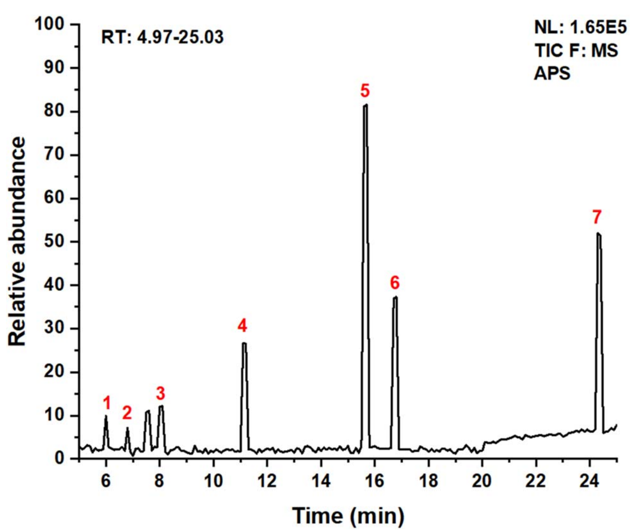

Fig. 7 GC-MS chromatogram for the monosaccharide composition of the polysaccharide isolated from amla pomace sweetmeat (1-xylose; 2- mannose; 3- glucose; 4- rhamnose; 5- galacturonic acid; 6- arabinose; 7- galactose).

a positive impact on the chewiness of the sweetmeat sample. The key factor influencing chewiness of a food product is its hydrocolloid content. Additionally, the interaction of proteins with water is a significant factor in the chewiness. Herein, adding fibre-rich pomace in the sweetmeat prevents water from reaching the available protein and other hydrocolloids, owing to the high-water holding capacity of fibre, thereby delaying the creation of a chewy structure in the pomace sweetmeat sample, despite the presence of khoa protein imparted by the 30% khoa present in S4. Thus, chewiness was higher in case of the amla pomace sweetmeat (160.5 g mm) in contrast to the control (138.9 g mm).

3.2.4. Monosaccharide profiling of polysaccharide fractions of the amla pomace sweetmeat. Polysaccharides are synthesized through dehydration and condensation of various monosaccharide units. Identifying the types and amounts of these monosaccharides is crucial for further understanding the conformation and structure–activity relationships of polysaccharides.[40] Therefore, the polysaccharides present in the amla pomace sweetmeat were first extracted, followed by their isolation and purification using methods described in the materials and methods section. Further, its monosaccharide composition was analysed using GC-MS. During the experiment, the multiple freeze–thaw cycles, depigmentation using 30% H_2O_2, dialysis, and freeze-drying of the sweetmeat sample resulted in the polysaccharide fraction powder. The purity of the obtained polysaccharide fraction was determined to be 99.01%, based on the area normalization method. This indicated that the obtained powder was a homogeneous polysaccharide, making it suitable for further analysis of monosaccharide composition. The GC-MS chromatogram for analysis of the monosaccharide composition of the polysaccharide fraction isolated from the amla-pomace sweetmeat is illustrated as Fig. 7. The results showed that the polysaccharide was composed of galactose, galacturonic acid, arabinose, and rhamnose in the molar ratio 41.4%:15.6%:12.9%:13.8%. Also, xylose, glucose and mannose were detected in smaller quantities. The presence of these monosaccharides in amla pomace sweetmeat is seconded by the fact that polysaccharides present in gooseberry are reported to be composed of galacturonic acid, galactose, rhamnose, arabinose, glucose, xylose and mannose.[41] Besides, polysaccharides found in coconut have been reported to consist of xylose, arabinose, galacturonic acid, galactose and glucose.[42]

4 Conclusion

Amla pomace, a by-product of amla juice extraction, is particularly abundant in vitamin C, phytochemicals, and dietary fibre, and shows strong potential in functional food development. This study explored the incorporation of amla pomace into dairy-based sweetmeats as a partial replacement for khoa to enhance their nutritional and functional properties. Fuzzy logic modelling of sensory data showed that replacement of khoa with amla pomace was very well accepted, with samples containing 30% khoa, 22.5% amla pomace, 7.5% desiccated coconut, and 40% sugar (S4) as the best sweetmeat sample. Besides, the preference ranking of samples based on their similarity values was S4 > S3 > S2 > S1 > S5 > S6. The selected sensory attributes were found to follow the general order of preference for the sweetmeats' quality criteria as follows OA > BT > F > CA. Furthermore, the best functional sweetmeat sample (S4) was found to contain 3.97% dietary fiber and significantly higher levels of ascorbic acid (98.71 mg/100 g) and phenolics (54.65 mg GAE/g), although fat and protein contents were slightly lower than those of the control. Also, the former sample exhibited increased hardness, cohesiveness, and chewiness. Besides, monosaccharides such as galactose, arabinose, glucose, and others were identified in polysaccharides isolated from amla pomace sweetmeat. Overall, the study confirms that amla pomace is a potential ingredient and can be utilized for the development of various food formulations with promising sensory and health attributes. Besides, the results also reveal that the sensory attributes of APS stored for 6 days under ambient conditions were found to be at par with the fresh samples. However, there is further scope of research to examine the effect of storage on the textural, nutritional, and microbial quality of amla pomace sweetmeat.

Data availability

The supporting data in the study will be provided by the corresponding author upon the appropriate request.

Author contributions

The author SF wrote the first draft of the manuscript. VK contributed as the senior author to critically revise the manuscript and gave its final shape. All authors have read, critically reviewed, and approved the final manuscript.

Conflicts of interest

The authors declare that there is no conflict of interests.

Sustainability spotlight statement

Countries around the globe are struggling with organic waste management due to the constant increase in waste generated in food processing units; hence, efforts to decrease food loss and waste together with steps to use the generated waste are necessary. Pomace, as a significant by-product of the juice processing industry, is projected to be underutilized, with only 20% of the total produced mass being used as organic fertilizer, animal feed or a substrate for fermentation. However, its full potential is yet to be explored owing to it being an abundantly opulent source of polyphenols, dietary fibre, vitamins, minerals, *etc.* Further, its utilization as a functional ingredient in food products would enhance its nutritional, functional, textural and sensory profiles. In addition, exploration of a sustainable method for using the generated waste will ensure improved efficiency of the food system and food security, while contributing to environmental sustainability. Therefore, this study, based on the valorisation of amla pomace for development of sweetmeats contributes to the United Nations sustainability development goals: good health and well-being (SDG 3) and responsible consumption and production (SDG 12).

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