Instrumental and sensory analysis of preconditioned cashew nut

Swapnali Borah and Ashok Kumar

Abstract

Instrumental and sensory analysis of roasted cashew nut and steamed cashew nut, produced in the state of Meghalaya, was performed. A tristimulus colorimeter was used to measure colour of cashew nut. Hardness of cashew nut was measured by texture analyser. Fifteen semi-trained judges were selected for collecting sensory data of cashew nut samples based on sensory quality attributes of colour, hardness, taste and mouth feel. Five point sensory scales (Not satisfactory, Fair, Medium, Good and Excellent) were used for evaluation of sensory data of cashew nut samples. The sensory data were analyzed by using fuzzy logic to find out the relative importance of the quality attributes of cashew nut samples in general, ranking of the cashew nut samples and ranking of individual quality attributes of each of the cashew nut samples tested. The results of fuzzy logic revealed that steamed cashew nut was preferred over roasted cashew nut in terms of colour, taste and mouth feel. The hardness of the steamed cashew nut was comparable with the hardness of the roasted cashew nut on 6-point standard fuzzy scale. The measured values of harness of roasted and steamed cashew nut were not significantly different (α = 0.05).

Keywords: Cashew nut, sensory analysis, fuzzy logic, hardness of cashew nut

1. Introduction

Cashew nut (Anacardium occidentale) is found abundantly in the Meghalaya, India. Agro climatic condition of Meghalaya: sandy loam soil, heavy rainfall along with hilly topography is very favourable for growing cashew nut. It is a popular cash crop worldwide and often found it in the serving plate of rich man embedded with lots of nutritive value. In India, cashew nut was initially introduced in Goa, and later expanded to western states of India and southern region of Kerala, Tamil Nadu, Karnataka and Andhra Pradesh (Kumar et al. 2012) [3]. In the North-Eastern states of India, cultivation of cashew nut is commonly found in Meghalaya, some parts of Assam, and Tripura.

Cashew nut either roasted or steamed before shelling of shell of cashew nut. Roasting or steaming of cashew nut shell help very much in shelling/ decortication of nut and also provide other benefits in terms of by-products (Kahyaoglu and kaya, 2006; Shakerardekani et al., 2011) [4, 9]. The process of roasting and steaming also affect the sensory quality of cashew nut in terms of colour, taste, hardness and mouth feel.

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) [10]. 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) [3, 8]. However, Instrumental analysis of parameters is preferred over sensory evaluation. In fact, instrumental and sensory analysis, both, are required in case of food product development and quality analysis.

Fuzzy set theory was introduced by Zadeh (1965) [11], which allows uncertain phenomena to be treated mathematically. Chen (1988) [3] developed a fuzzy comprehensive model for analyzing sensory data. In this work, sensory analysis of roasted cashew nut and steamed cashew nut, produced in the state of Meghalaya, was performed using fuzzy logic approach. Ranking of cashew nut samples and their quality attributes was carried out using triangular fuzzy membership distribution function (Das, 2005) [3]. Instrumental analysis of colour and hardness of cashew nut samples is also presented and compared with sensory data.

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2. Materials and Methods
2.1 Cashew nut samples
Roasted cashew nut and steamed cashew nut were collected from the local factories functioning in the state of Meghalaya, India. Colour, moisture content and hardness of cashew nuts were measured using instruments and assessment of sensory quality of cashew nuts was performed by trained panel members.

2.2 Instrumental analysis of cashew nut samples
Moisture content of cashew nut samples were measured by heating the samples in hot air oven at 105 ± 1 °C for 24 hours. A tristimulus colorimeter (Chroma Meter CR = 400, Konica Minolta, Japan) was used to measure and compare the colour (L, a, b) of cashew nut samples. The hardness of cashew nut samples was measured with the help of texture analyzer (Model TA-XT plus). The probe, HDP/BSK blade set with knife, and heavy duty platform were used to measure force required to cut cashew nut shell.

2.3 Assessment of Sensory Quality of Cashew Nuts
Fifteen judges, all non-smokers and non-beetle leaf chews were selected based on good health, average sensitivity, interest in sensory evaluation, ability to concentrate and learn and familiarity with the cashew nut samples. Quality attributes selected for sensory evaluation were colour, hardness, taste, and mouthfeel. Judges were familiarized with the definition of quality attributes, scorecard and the method of scoring. Judging was done during 10:00 AM to 12:00 PM. They were asked to practice the scoring procedure according to the definition of each of the quality attributes before the actual test. They were asked to judge the samples quickly, but not in hurry. They were advised to rinse their mouth with water between testing the consecutive samples. Steamed cashew nut was labeled as sample S1 and roasted cashew nut was labeled as sample S2. Judges were asked to give tick (√) mark to the respective scale factor for each of quality attributes mentioned in the scorecard. They were also asked to rank the quality attributes of cashew nut samples in general, by giving tick (√) mark to appropriate scale factors.

Five point sensory scales viz., Not satisfactory (NS), Fair (F), Medium (M), Good (G), Excellent (E), were used for evaluation of cashew nut samples. Judges were also asked to evaluate the relative importance of four quality attributes (viz., colour, hardness, taste and mouth feel) on the five-point sensory scale. Not at all important (NI), Somewhat important (SI), Important (I), Highly important (HI), Extremely important (EI), for the cashew nut in general. The results were analyzed by using fuzzy logic to find out the relative importance of the quality attributes of cashew nut samples in general, ranking of the two samples and ranking of individual quality attributes of each of the three samples tested. Details of fuzzy comprehensive modeling of scores have been described in the following sections (Basak, 2018; Mukhopadhyay et al., 2013) [1, 6].

2.4 Fuzzy comprehensive modeling of sensory scores
Ranking of cashew nut samples and their quality attributes was carried out using triangular fuzzy membership distribution function (Fig.1) (Das, 2005) [3]. In the triangular fuzzy membership distribution, sensory scales are represented by a set of three members called ‘triplets’ (Table 1 and Table 2). Sensory scores of cashew nut samples and their quality attributes are converted into triplets, which were used for the estimation of similarity values needed for the ranking of samples.

![Fig 1: Values of triplets associated with triangular fuzzy membership distribution function for five-point sensory scale](image)

Table 1: Triplets associated with sensory scales for quality attributes of cashew nut samples

<table>
<thead>
<tr>
<th>Not satisfactory / Not at all important</th>
<th>Fair / Somewhat important</th>
<th>Medium / Important</th>
<th>Good / Highly important</th>
<th>Excellent / Extremely important</th>
</tr>
</thead>
<tbody>
<tr>
<td>0, 0, 25</td>
<td>25, 25, 75</td>
<td>50, 25, 75</td>
<td>75, 25, 75</td>
<td>100, 25, 0</td>
</tr>
</tbody>
</table>

Table 2: Triplets associated with sensory scales for relative importance of quality attributes of cashew nut samples

<table>
<thead>
<tr>
<th>Not at all important</th>
<th>Somewhat important</th>
<th>Important</th>
<th>Highly important</th>
<th>Extremely important</th>
</tr>
</thead>
<tbody>
<tr>
<td>0, 0, 25</td>
<td>25, 25, 75</td>
<td>50, 25, 75</td>
<td>75, 25, 75</td>
<td>100, 25, 0</td>
</tr>
</tbody>
</table>

2.5 Steps involved in fuzzy modeling of sensory evaluation of cashew nut samples are given below
1. Calculation of sensory scores for quality attributes of cashew nut samples by counting the responses of judges at that sensory point for that particular quality attribute.
2. Calculation of sensory scores for relative importance of quality attributes of cashew nut samples in general by counting the responses of judges at that sensory point for that particular quality attribute.
3. Calculation of the triplets for sensory scores of the quality attributes of cashew nut samples using the following equation:

\[ S1C = \frac{\sum_{i=1}^{w}s_{i}(sensory\ score)\cdot s_{i}(triplets)}{\text{total no.of judges}} \] (1)

Where \( S1C \) is triplets for sensory scores of colour for sample 1, \( s_{i}(sensory\ score) \) is sensory score at \( i^{th} \) sensory point on five-point sensory scale corresponding to colour for sample 1 and \( s_{i}(triplets) \) is triplets associated with \( i^{th} \) sensory point on five-point sensory scale.

Similarly, triplets for sensory scores of colour, hardness, taste and mouth feel for sample 1 and sample 2 were calculated.

4. Calculation of the triplets for sensory scores of relative importance of the quality attributes for cashew nut samples using the following equation:

\[ QC = \frac{\sum_{i=1}^{w}s_{i}(sensory\ score)\cdot s_{i}(triplets)}{\text{total no.of judges}} \] (2)

Where \( QC \) is triplets for sensory scores of colour in general for cashew nut sample, \( s_{i}(sensory\ score) \) is sensory score at
i\textsuperscript{th} sensory point on sensory scale for relative importance of quality attributes corresponding to colour and (triplets), is triplets associate with i\textsuperscript{th} sensory point on five-point sensory scale for relative importance of quality attributes. Similarly, QH, QT and QM, triplets for sensory scores of hardness, taste and mouth feel in general respectively were calculated.

5. Calculation of triplets for relative weightage of quality attributes of cashew nut samples from the triplets of quality attributes in general using the following equations:

\[
Q_{C_{rel}} = \frac{Q_C}{Q_{sum}}
\]

\[
Q_{H_{rel}} = \frac{Q_H}{Q_{sum}}
\]

\[
S01 = S1C \times Q_{C_{rel}} + S1H \times Q_{H_{rel}} + S1T \times Q_{T_{rel}} + S1M \times Q_{M_{rel}}
\]

\[
S02 = S2C \times Q_{C_{rel}} + S2H \times Q_{H_{rel}} + S2T \times Q_{T_{rel}} + S2M \times Q_{M_{rel}}
\]

7. Calculation of membership function of sensory scores on standard fuzzy scale:

Fig. 2 shows ‘standard fuzzy scale’ following triangular distribution pattern of 6-point sensory scale. The six points on fuzzy scale are represented as F1, F2, F3, F4, F5 and F6 corresponding to Not satisfactory/Not at all necessary, Fair/Somewhat necessary, Satisfactory/Necessary, Good/Important, Very good/Highly important, Excellent/Extremely Important respectively. The values of fuzzy membership function for each of the sensory points on fuzzy scale follow triangular distribution pattern with maximum and minimum values equal to 1 and 0 respectively. The maximum values of fuzzy membership function for each interval of 10, i.e., (10-0), (20-10), (30-20), (40-30), (50-40), (60-50), (70-60), (80-70), (90-80) and (100-90) on ‘standard fuzzy scale’ were opted as the values of membership function for particular sensory point based on its triangular distribution pattern on the fuzzy scale. Referring to the Fig. 2, the values of membership function for each of the six sensory points on fuzzy scale (viz., F1, F2, F3, F4, F5 and F6) are given in the form of row matrix having 10 elements as shown below:

\[
F1 = (1, 0, 0, 0, 0, 0, 0, 0, 0, 0)
\]

\[
F2 = (0.5, 1, 0.5, 0, 0, 0, 0, 0, 0, 0)
\]

\[
F3 = (0, 0.5, 1, 0.5, 0, 0, 0, 0, 0, 0)
\]

\[
F4 = (0, 0, 0, 0.5, 1, 0.5, 0, 0, 0, 0)
\]

\[
F5 = (0, 0, 0, 0, 0, 1, 0.5, 0.5, 0, 0)
\]

\[
F6 = (0, 0, 0, 0, 0, 0, 0, 1, 0.5, 1)
\]

\[
\begin{align*}
Q_{T_{rel}} &= \frac{QT}{Q_{sum}} \\
Q_{M_{rel}} &= \frac{QM}{Q_{sum}} \\
Q_{H_{rel}} &= \frac{QH}{Q_{sum}} + QT + QM
\end{align*}
\]

Where QC\textsubscript{rel}, QH\textsubscript{rel}, QT\textsubscript{rel} and QM\textsubscript{rel} are triplets corresponding to the relative weightage of colour, Hardness, taste and mouthfeel respectively of the cashew nut samples and QC, QH, QT and QM are.

6. Calculation of triplets for overall sensory score of cashew nut samples from the triplets for quality attributes of sample and the triplets for the relative weightage of quality attributes following using following equation:

\[
S01 = S1C \times Q_{C_{rel}} + S1H \times Q_{H_{rel}} + S1T \times Q_{T_{rel}} + S1M \times Q_{M_{rel}}
\]

\[
S02 = S2C \times Q_{C_{rel}} + S2H \times Q_{H_{rel}} + S2T \times Q_{T_{rel}} + S2M \times Q_{M_{rel}}
\]

8. Calculation of overall membership function of sensory scores on standard fuzzy scale:

The graphical representation of membership function for triplet (a b c) is shown in Fig. 3. The abcissa represents value corresponding to triplet and ordinate represents value of membership function for triplet (a b c). For a given value of x on the abcissa, value of membership function B\textsubscript{x} can be expressed as equation,

\[
B_x = \begin{cases} 
\frac{x-(a-b)}{b} & \text{for } (a - b) < x < a \\
\frac{(a+c)-x}{c} & \text{for } a < x < a + c \\
0 & \text{for all other values of } x
\end{cases}
\]

The values of membership function B\textsubscript{x} at x = 0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 were evaluated using equation 4.11 for triplets of overall sensory scores of cashew nut samples. The value of membership function of sensory scores of the sample on standard fuzzy scale is given by set of ten numbers, which are, maximum value of B\textsubscript{x} at 0 < x < 10, maximum value of B\textsubscript{x} at 10 < x < 20, maximum value of B\textsubscript{x} at 20 < x < 30, maximum value of B\textsubscript{x} at 30 < x < 40, maximum value of B\textsubscript{x} at 40 < x < 50, maximum value of B\textsubscript{x} at 50 < x < 60, maximum value of B\textsubscript{x} at 60 < x < 70, maximum value of B\textsubscript{x} at 70 < x < 80, maximum value of B\textsubscript{x} at 80 < x < 90 and maximum value of B\textsubscript{x} at 90 < x < 100. The overall membership functions of sensory scores of samples on standard fuzzy scale were represented by row matrix having 10 elements and denoted as B1 and B2 for sample 1, and sample 2 respectively.
9. Calculation of similarity values and the ranking of cashew nut samples:

After calculating the values of overall membership function of sensory scores of cashew nut samples on standard fuzzy scale, these values were compared with the values of membership function for each of the six sensory points (F1, F2, F3, F4, F5 and F6) on standard fuzzy scale. The similarity values for each of the sample were calculated using equation given below:

\[
S_m (F, B) = \frac{F \times B^T}{\text{Max} (F \times F^T \text{ and } B \times B^T)}
\]  

(7)

Where \( S_m (F, B) \) is similarity value corresponding to sensory scale point F for sample having overall membership function B. The \( F^T \) and \( B^T \) are transpose of matrix F and B respectively. The similarity values for sample 1 and sample 2 were calculated using Eq. (7). The cashew nut samples having highest similarity value was ranked higher and cashew nut samples having lower similarity value was ranked lower.

10. Calculation of quality attribute ranking of cashew nut samples in general:

Similar procedure as followed in earlier section (vii, viii and ix) was used to calculate quality attribute ranking of cashew nut samples in general. The values of membership function of sensory score for relative importance of quality attributes of cashew nut samples were calculated from the triplets for sensory score of relative importance of quality attributes using Eq. (6) and denoted as BC, BH, BT and BM for colour, hardness, taste and mouth feel respectively. Similarity values for each quality attributes in general were calculated from values of BC, BH, BT and BM and values of F1, F2, F3, F4, F5 and F6 using Eq.(7). The quality attribute having highest similarity values was ranked higher and quality attribute having lower similarity values was ranked lower.

11. Calculation of quality attribute ranking of individual cashew nut sample:

Similar procedure as followed to evaluate the quality attribute ranking of cashew nut sample in general was used to calculate quality attribute ranking of individual cashew nut sample. Here, triplets for overall sensory scores for colour, hardness, taste and mouth feel of sample 1 were calculated from triplets for overall sensory scores of cashew nut sample in general using relative weightage for these quality attributes. For this, average sum (\( Q_{\text{sum}} \)) of first digit of triplets QC, QH, QT and QM was used. The triplets of relative weightage of quality attributes of sample 1 were calculated from the triplets of quality attributes in general using the following equation:

\[
QC_{rel} = \frac{QC}{Q_{\text{sum}}} \\
QA_{rel} = \frac{QA}{Q_{\text{sum}}} \\
QT_{rel} = \frac{QT}{Q_{\text{sum}}} \\
QM_{rel} = \frac{QM}{Q_{\text{sum}}}
\]  

(8)

Where \( Q_{\text{sum}} = \frac{1}{4} \times (QC_1 + QA_1 + QT_1 + QM_1) \)

Where QC1, QA1, QT1 and QM1 are triplets corresponding to sensory score of colour, hardness, taste and mouth feel respectively for sample 1. These triplets were converted into membership function for relative importance of quality attributes of sample 1 using Eq. 4.11 and denoted as BC1, BA1, BT1 and BM1 for colour, hardness, taste and mouth feel respectively. Further, these values of membership function were converted into similarity values using Eq. 6 and comparison was done to find out the higher and lower ranks of quality attributes of sample 1. The same process was followed for other samples to rank their quality attributes.

3. Results and Discussion

3.1 Moisture content of cashew nut samples

Mean values of the measured quality parameters of cashew nut samples are listed in Table 3. The measured values of moisture content of roasted and steamed cashew nut were 12.13 ± 0.63 and 12.68 ± 0.54, respectively. Statistical analysis showed that the moisture content of roasted cashew nut and steamed cashew nut were not significantly different at \( \alpha = 0.05 \). Hence, it was reasonable to compare the colour and hardness of these cashew nut samples because these qualities were dependent of moisture content which varied with processing condition.
3.2 Colour of cashew nut samples
Colour of cashew nut was influenced by the processing conditions like roasting or steaming method of processing. Roasted cashew nut and steamed cashew nut used in this study are shown in Figure 4. Mean values of the measured colour parameters of cashew nut samples are listed in Table 3. The lightness value (L*) and hue angle (h*) of roasted cashew nut and steamed cashew nut were significantly different (α = 0.05). The steamed cashew nut (L* = 70.15 ± 4.58) was lighter than the roasted cashew nut (L* = 64.92 ± 2.99). Comparison of hue angle of roasted and steamed cashew nuts indicated that the roasted cashew nut was less yellowish that the steamed cashew nut. The different colour in roasted and steamed cashew nut was developed due to roasting/steaming and further drying of cashew nut. Statistical analysis of data showed that chroma value (C*) of roasted cashew nut and steamed cashew nut were not significantly different. Hence, degree of saturation of colour of roasted and steamed cashew nuts was similar.

![Fig 4: Roasted cashew nut and steamed cashew nut used in this study](image)

3.3 Hardness of cashew nut samples
Figure 5 shows the cutting strength of roasted and steamed cashew nut samples which were measured using the texture analyzer. The mean values of hardness of roasted and steamed cashew nut were 2303.94 ± 521.72 and 2135.86 ± 541.81, respectively. Statistical analysis of data showed that the hardness of roasted cashew nut and steamed cashew nut were not significantly different at 0.05 level of significant. Hence, processing steps like roasting and steaming of cashew nut did not influence the hardness of cashew nut significantly if moisture content of cashew nut samples were same. However, fracture strength of roasted and steamed cashew nut shell depended on roasting and steaming, respectively (Ogunsina and Bamgboyce, 2013) [7].

![Fig 5: cutting strength of cashew nut samples](image)

3.4 Sensory Quality of Cashew Nuts
The sum of the responses obtained for cashew nut samples by fifteen judges are shown in Table 4 for sensory scores of quality attributes of cashew nut samples and in Table 5 for sensory scores of relative importance of quality attributes of cashew nut in general. The triplets associated with the sensory scores for quality attributes of cashew nut samples were calculated using Eq. (1) and are presented in Table 6.

<table>
<thead>
<tr>
<th>Sensory quality attributes for cashew nut samples</th>
<th>Samples</th>
<th>Sensory scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>S1</td>
<td>0 0 3 12 0</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>1 2 7 5 0</td>
</tr>
<tr>
<td>Hardness</td>
<td>S1</td>
<td>0 1 2 12 0</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>2 1 5 5 2</td>
</tr>
<tr>
<td>Taste</td>
<td>S1</td>
<td>0 0 2 10 3</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>2 0 7 4 2</td>
</tr>
<tr>
<td>Mouthfeel</td>
<td>S1</td>
<td>0 0 2 10 3</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>2 1 6 5 1</td>
</tr>
</tbody>
</table>

Table 4: Sum of sensory scores for quality attributes of cashew nut

<table>
<thead>
<tr>
<th>Quality attributes of cashew nut samples in general</th>
<th>Sensory scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>0 0 5 6 4</td>
</tr>
<tr>
<td>Hardness</td>
<td>0 0 4 7 4</td>
</tr>
<tr>
<td>Taste</td>
<td>0 0 3 6 6</td>
</tr>
<tr>
<td>Mouthfeel</td>
<td>0 0 6 7 2</td>
</tr>
</tbody>
</table>

Table 5: Sum of sensory scores for relative importance of quality attributes of cashew nut in general
The triplets for sensory scores of relative importance of the quality attributes of cashew nut in general were calculated using Eq. (2) and are presented in Table 7. The triplets of relative weightage of quality attributes of cashew nut were calculated from the triplets of quality attributes of cashew nut in general using Eq. (3) and are presented in Table 7.

**Table 6: Triplets for sensory scores of the quality attributes of the cashew nut**

<table>
<thead>
<tr>
<th>Sensory quality attributes for cashew nut samples</th>
<th>Triplets for sensory scores</th>
<th>Triplets for relative weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>S1C=(70, 25, 25)</td>
<td></td>
</tr>
<tr>
<td>Hardness</td>
<td>S2C=(51,67, 23,33, 25)</td>
<td></td>
</tr>
<tr>
<td>Taste</td>
<td>S1A=(68,33, 25, 25)</td>
<td></td>
</tr>
<tr>
<td>Mouthfeel</td>
<td>S2A=(36,67, 21,67)</td>
<td></td>
</tr>
</tbody>
</table>

**Table 7: Triplets for sensory scores of relative importance of the quality attributes of cashew nut in general**

<table>
<thead>
<tr>
<th>Quality attributes of cashew nut in general</th>
<th>Triplets for sensory scores</th>
<th>Triplets for relative weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>QC=(73,33, 25, 18,33)</td>
<td>QCM=(0.25, 0.08, 0.06)</td>
</tr>
<tr>
<td>Hardness</td>
<td>QA=(75, 25, 18,33)</td>
<td>QAM=(0.25, 0.08, 0.06)</td>
</tr>
<tr>
<td>Taste</td>
<td>QT=(80, 25, 15)</td>
<td>QT=(0.27, 0.08, 0.05)</td>
</tr>
<tr>
<td>Mouth feel</td>
<td>QM=(68,33, 25, 21,67)</td>
<td>QM=(0.23, 0.08, 0.07)</td>
</tr>
</tbody>
</table>

The triplets for overall sensory scores of cashew nut samples were calculated from the triplets for quality attributes of sample and the triplets for the relative weightage of quality attributes using Eq. (4). The triplets for overall sensory scores of the two cashew nut samples are presented below.

\[
S01 = (72.91, 49.57, 40.52) \\
S02 = (54.66, 40.47, 36.32) \\
\]

The values of overall membership function of sensory score of cashew nut samples on standard fuzzy scale, B₁ at x= 0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 were evaluated using equation (5) for triplets of overall sensory scores of cashew nut samples. The overall membership functions of sensory scores of sample 1 and sample 2 on standard fuzzy scale are given below and denoted as B₁ and B₂ respectively.

\[
B1 = (0.0, 0.0, 0.13, 0.34, 0.54, 0.64, 0.74, 0.94, 0.83, 0.58) \\
B2 = (0.0, 0.14, 0.39, 0.64, 0.88, 0.85, 0.61, 0.58, 0.30, 0.03) \\
\]

After calculating the values of overall membership function of sensory scores of cashew nut samples on standard fuzzy scale, these values were compared with the values of membership function for each of the six sensory points (F1, F2, F3, F4, F5 and F6) on standard fuzzy scale and similarity values for each sample were calculated using Eq. (6). The similarity values obtained for two cashew nut samples are presented in Table 8.

**Table 8: Similarity values for the two cashew nut samples**

<table>
<thead>
<tr>
<th>Sensory scales</th>
<th>Sample 1</th>
<th>Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Satisfactory, F1</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>Fair, F2</td>
<td>0.09</td>
<td>0.29</td>
</tr>
<tr>
<td>Satisfactory, F3</td>
<td>0.38</td>
<td>0.74</td>
</tr>
<tr>
<td>Good, F4</td>
<td>0.65</td>
<td>0.76</td>
</tr>
<tr>
<td>Very Good, F5</td>
<td>0.74</td>
<td>0.42</td>
</tr>
<tr>
<td>Excellent, F6</td>
<td>0.30</td>
<td>0.06</td>
</tr>
<tr>
<td>Ranking</td>
<td>I</td>
<td>II</td>
</tr>
</tbody>
</table>

It was evident from the Table 8 that highest similarity values for sample 1 and sample 2 were 0.74 under the sensory scale of ‘Very Good’ and 0.76 under the sensory scale of ‘Good’ respectively on 6-point sensory scale. The cashew nut samples were ranked according to the highest similarity values on 6-point sensory scale. Following this rule, the overall sensory qualities of sample 1 and sample 2 were considered ‘Very Good’, and ‘Good’ respectively. Sample 1 was ranked higher because it had similarity value higher than the sample 2. Thus, the order of ranking of cashew nut samples on 6-point sensory scale was found as given below:

**Sample 1 (Very good) > Sample 2 (Good)**

Thus, it can be concluded that steamed cashew nut (sample 1) was higher in terms of sensory quality attributes than the roasted cashew nut (sample 2).

The similarity values of the quality attributes of cashew nut in general were calculated from the values of membership function of sensory score for relative importance of quality attributes of cashew nut in general and the values of membership function for each of the 6-points sensory scale using Eq. (6). The similarity values of the quality attributes of cashew nut in general are presented in the Table 9.

**Table 9: Similarity values of the quality attributes of cashew nut in general**

<table>
<thead>
<tr>
<th>Quality attributes of cashew nut in general</th>
<th>Similarity values</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all necessary</td>
<td>0.00</td>
<td>4</td>
</tr>
<tr>
<td>Somewhat necessary</td>
<td>0.00</td>
<td>3</td>
</tr>
<tr>
<td>Necessary</td>
<td>0.01</td>
<td>2</td>
</tr>
<tr>
<td>Important</td>
<td>0.39</td>
<td>1</td>
</tr>
<tr>
<td>Highly important</td>
<td>0.71</td>
<td>I</td>
</tr>
<tr>
<td>Extremely important</td>
<td>0.30</td>
<td>II</td>
</tr>
</tbody>
</table>

The highest similarity values for colour, hardness, taste and mouthfeel of cashew nut were 0.71 under the sensory scale of ‘Highly Important’, 0.78 under the sensory scale of ‘Highly Important’, 0.94 under the sensory scale of ‘Highly Important’ and 0.82 under the sensory scale of ‘Important’ respectively on 6-point sensory scale as shown in Table 9. Thus, the order of ranking of quality attributes of cashew nut in general was...
as given below:

Taste (Highly important) > Hardness (Highly important) > Colour (Highly important) > Mouth feel (Important)

The similarity values of quality attributes of individual cashew nut samples are presented in Table 10. It was evident from Table 10 that highest similarity values for colour, hardness, taste and mouth feel of sample 1 were under sensory scale of ‘Very Good’ (0.78), ‘Good’ (0.69), ‘Very Good’ (0.80) and ‘Very good’ (0.75) respectively. Similarly, the highest similarity values for colour, hardness, taste and mouth feel of sample 2 were under sensory scale of ‘Good’ (0.86), ‘Good’ (0.85), ‘Good’ (0.89) and ‘Satisfactory’ (0.75) respectively. On comparing the similarity values of quality attributes of individual cashew nut samples, ranking of quality attributes of individual sample was for:

**Sample 1**

Taste (Very good) > Colour (Very Good) > Mouthfeel (Very Good) > Hardness (Good)

**Sample 2**

Taste (Good) > Colour (Good) > Hardness (Good) > Mouthfeel (Satisfactory)

| Table 10: Similarity values and ranking of quality attributes of individual cashew nut samples |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Sensory scales                  | Sample 1                        | Sample 2                        |                                 |                                 |                                 |                                 |                                 |                                 |
|                                 | C     | H     | T     | M     | C     | H     | T     | M     |                                 |                                 |                                 |                                 |                                 |
| Not Satisfactory, F1           | 0.00  | 0.00  | 0.00  | 0.00  | 0.04  | 0.02  | 0.01  | 0.04  |                                 |                                 |                                 |                                 |                                 |
| Fair, F2                       | 0.10  | 0.11  | 0.03  | 0.11  | 0.28  | 0.28  | 0.21  | 0.35  |                                 |                                 |                                 |                                 |                                 |
| Satisfactory, F3               | 0.34  | 0.41  | 0.28  | 0.39  | 0.68  | 0.80  | 0.71  | 0.75  |                                 |                                 |                                 |                                 |                                 |
| Good, F4                       | 0.69  | 0.69  | 0.59  | 0.66  | 0.86  | 0.85  | 0.89  | 0.70  |                                 |                                 |                                 |                                 |                                 |
| Very Good, F5                  | 0.78  | 0.63  | 0.80  | 0.75  | 0.41  | 0.31  | 0.38  | 0.30  |                                 |                                 |                                 |                                 |                                 |
| Excellent, F6                  | 0.29  | 0.24  | 0.42  | 0.28  | 0.04  | 0.02  | 0.03  | 0.03  |                                 |                                 |                                 |                                 |                                 |
| Ranking                        | II    | IV    | I     | III   | II    | III   | I     | IV    |                                 |                                 |                                 |                                 |                                 |

The similarity value for taste of sample 1 and sample 2 were under the category of ‘Very good’ and ‘Good’ respectively which was ranked first under ‘Highly important’ quality attributes of cashew nut in general. The similarity values for mouth feel of sample 1 and sample 2 were under the category of ‘Very good’ and ‘Satisfactory’ which was ranked second under ‘Important’ quality attribute of cashew nut in general. The similarity value for hardness of sample 1 and sample 2 were under the category of ‘Good’. The quality attribute, hardness, of cashew nut was ranked second under ‘Highly important’ quality attributes of cashew nut in general. The quality attribute, hardness, of cashew nut of sample 1 and sample 2 was comparable, because it was under the category of ‘Good’ for both samples. The measured values of hardness of roasted and steamed cashew nuts were also not significantly different.

The similarity values for colour of sample 1 and sample 2 were under the category of ‘Very good’ and ‘Good’ respectively which was ranked third under ‘Highly Important’ quality attributes of cashew nut in general. Hence, judges perceived different colour for roasted and steamed cashew nut. The differences in colour of roasted and steamed cashew nut were also measured during instrumental analysis of colour of cashew nut.

4. Conclusions

It can be concluded that the steamed cashew nut (sample 1) was better than the roasted cashew nut in terms of quality attributes taste, colour and mouth feel on 6-point sensory scale. Further, it can also be concluded that quality attribute, hardness of the steamed cashew nut (sample 1) was comparable with hardness of the roasted cashew nut (sample 2) on 6-point sensory scale. The measured values of hardness of roasted and steamed cashew nut were not significantly different (α = 0.05). The differences in colour of roasted and steamed cashew nut were also measured by instrument and also perceived by the judges.

5. Acknowledgement

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6. References