Comparative quality evaluation of commercial extruded snacks

Amudha Senthil\(^1\), Bharath Kumar S.\(^1\), Aparna Pathak\(^2\)

\(^1\)Department of Sensory Science, CSIR-Central Food Technological Research Institute (CFTRI), Mysore-570020, India.
\(^2\)Department of Food Technology, Centre for Food Technology Jiwaji University, Gwalior, India.

*Corresponding author E-mail: amudhasen12@yahoo.com, Tel: 0821-2515842

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Five commercially extruded snacks with different flavours were subject to sensory tests to determine the variations in the flavour quality. The different flavours of snack were labeled as S\(_1\) (Masala), S\(_2\) (Chilli), S\(_3\) (Pudina), S\(_4\) (Tomato) and S\(_5\) (Spicy). Only slight changes were observed in Moisture, Peroxide Value and Free Fatty Acid content, which were within the safe level over 60 days of under different conditions. The texture of the product is measured in terms of the peak force, reflected hardness. Samples S\(_1\) and S\(_4\) were harder than S\(_5\). Certain changes observed in some of the sensory attributes of all the samples during storage. All the snacks were acceptable even at the end of 60 days of storage. E-nose analysis showed that the initial samples were positioned away from the stored samples indicating change in volatile components. This study revealed that variations in the snack having different flavourings can be traced by adopting suitable sensory evaluation and instrumental technique.

Key words: Snack foods, electronic nose, texture analyzer, storage study, peroxide value, free fatty acid.

INTRODUCTION

Snack foods are designed to be less perishable, more durable and more appealing than natural foods. People eat snacks for pleasure and taste rather than for nutritive considerations. A snack food is defined as a type of food that is eaten in between main meals but not as a part of them. People want their snack food to be convenient, tasty, flavourful, satisfying, nutritious, low in calorie and sodium and inexpensive (Harper, 1981). The food industry has risen to face this challenge with many ideas such as incorporating vitamins and minerals, limiting the amount of oil absorbed during frying, thus reducing the amount of calories, improving flavour and texture and increasing the efficiency of production for keeping overall cost low (Dehghan-Shoar et al., 2010).

The snack food industry generates billions of dollars in revenue every year. The snack foods in general have a moisture content of 2 – 35%, fat 15 – 45%, protein 5 – 35%, ash 2 – 6% and starch 5 – 48% (Potty, 1993). Changes in lifestyle, particularly in the modern world, have consolidated the availability and sales of convenience foods providing considerable support for the expansion and globalization of coated foods.

The new generation snacks like, Lower fat, Baked not fried (khakra/dry chapathi, papad), High fiber products (products made from rice bran/wheat bran), Coated snacks are likely to have more market (Annapure et al., 1997). Low-fat fried products can be prepared by judicious blending of cereal and pulses, with some of the additives. Oil uptake is a surface phenomenon and surface related properties such as interfacial tension and surface hydrophobicity play a vital role in oil uptake by the product during frying (Annapure et al., 1998).

The Indian snack food market is large, diverse and dominated mainly by unorganized sectors such as cottage and small scale industries. India being a subcontinent has its own culture, food habits, customs and traditions. Indian snack food industry comprises of many Indian as well as MNCs. The consumers demand for Ready to eat snacks (RTE) is showing consistent growth due to the convenient nature of snack products at a reasonable price and also the appeal of RTE snacks for texture. Thus, it is necessary for the manufacturers to implement a reliable Quality assurance programme (Camire and King, 1991). Snacks market is classified into two major segments namely, Western and traditional, wherein western snacks enjoy more popularity in comparison to the traditional snacks. There was an increase in the financial state of the MNCs with these snack production since 2005, as the ratio of production is increased many folds due to demand of the snack foods.
in market (http://www.marketresearch.com). Products are categorized as RTE mixes, chips, curries, bakery products, namkeens and other processed foods. The list can be extremely long and with new products entering the food market nearly every day, the list is getting longer and longer (Fast, 1999). They also remember and continue to buy products with consistent high quality and perceived value. Recently there has been a steady growth in the production of extruded snacks. These snacks are becoming more popular in India which resulted in formulation of several extruded snacks with typical flavours to suit the taste preference of Indian consumer.

Extrusion technology is a High Temperature Short Time (HTST) process. In the extrusion of snacks and other food products, proper control of the extrusion process is of vital importance to the quality of the final product. The immediate vapourization of moisture expands and sets the product. After these initial processes, many cereals are dipped into slurry of sugar water and flavouring. However, in some cases, the sugar, flavouring and nutrients are added with the base. Extrusion is one of the most versatile operations available to the food industry for transforming ingredients into intermediate or finished products. These foods have been proven to provide nutritious products and combine quality ingredients and nutrients to produce processed foods that contain precise levels of each required nutrient. Extrusion cooking technology provides a method to process raw ingredients on large scale at a remarkably low cost (Seth & Rajamanickam, 2012).

Extrusion offers many advantages over spray drying and roller drying technologies, namely preparation of ready to eat foods of desired shape, size, texture and sensory characteristics at very low processing cost (Guy, 2001; Jamora et al., 2002). Some of the popular fried snacks of South India like Murukku, Kodubale, Tengolalu, Nankhatai are prepared using rice and legumes as main ingredients. Flour is made into stiff dough and extruded through hand press and fried (Arya, 1992). A number of research studies have been reported on baked products, extruded products and deep fat fried snacks made from cereal and legume flours (Rao et al., 2007; Ravi et al., 2011; Babu et al., 2013). There exists a great potential for the global food industry to manipulate the nutritional status of these products so as to offer the consumer RTE snacks with a range of nutritional profiles from highly digestible starch and protein products for people indulging in sport activities (Margaret et al., 2013).

Based on the review of literature, it is evident that no systematic study has been reported so far on the sensory profiling of extruded products using standard sensory methods. Moreover, the quality aspects on extruded samples from market have not been reported in detail. Hence, the aim of the present investigation was to study variation in the sensory quality of one type of snack having different flavourings by adopting suitable sensory and instrumental methods. The precision of electronic nose has also been evaluated in discriminating between head space volatiles of fresh and stored samples.

MATERIALS AND METHODS

Extruded snacks procurement

Five samples of commercial extruded snack with different flavours were procured from the local market of Mysore and subject to different sensory tests to determine the variation in their flavour quality. The different flavours of snack were labeled as S_1 (Masala), S_2 (Chilli), S_3 (Pudina) S_4 (Tomato) and S_5 (Spicy).

Sampling plan

A sampling plan is a detailed outline of which measurements will be taken at what times, on which material, in what manner. Sampling plans should be designed in such a way that the resulting data will contain a representative sample of the parameters of interest and allow for all questions, as stated in the goals, to be answered. A sampling plan schedule is mentioned in Table 1.

Chemical analysis

Extruded snacks were analysed for Moisture, Fat, Free Fatty Acid (FFA) and Peroxide Value (PV) according to the standard methods (AOAC, 1995). Five different flavours of the same extruded snacks were stored under three different conditions (refrigerated, ambient & accelerated) for the period of 60 days. Chemical analysis of extruded samples was done for initial, 30th and 60th days.

Sensory analysis

Extruded snacks were evaluated for their quality by employing two methods of sensory evaluations namely, ranking test and quantitative descriptive analysis (profiling).

Preference ranking test

The preference ranking test (Meilgaard et al., 1999) was conducted to evaluate the commercial extruded snacks. It was done by 39 panelists, consisting both trained and semi-trained members. The panelists were asked to rank the samples in the order of flavour preference (most preferred flavour gets the first rank and the least
preferred sample gets the lowest rank). Using Kramer’s rank sum test, the superior and inferior samples were identified (Kramer et al., 1979). The data thus obtained were analyzed statistically using Friedman’s test followed by Wilcoxon Mann-Whitney U-test. By this method all possible pairs of sample tested could be compared (BIS, 1983).

**Quantitative Descriptive Analysis (QDA)**

Profiling of the extruded snacks was conducted with the help of a trained sensory panel by the method of QDA (Stone et al., 1998) to get a detailed description of various attributes that influences the product acceptability. Descriptors were developed during initial sessions. Panelists were asked to describe the samples with as many spontaneous descriptive terms as they found applicable.

The common descriptors chosen by at least one third of the panel were compiled along with some impact making descriptors for the preparation of scorecard. The descriptors used in the evaluation are crispness, flavour intensity, spicy, lingering flavour, souness, sweetness, lingering taste and overall quality.

The panel consisted of 15 judges who regularly participated in sensory analysis and having experience in profiling of food products. The samples were served in petri- dishes coded with three digit numbers under two different sessions, to avoid fatigue. Evaluations were carried out in the boothrooms built in accordance with the ASTM standards (1996).

Sensory evaluation was done by the method of intensity scaling using a score card consisting of 10 cm scale, with ‘0’ and ‘10’ representing ‘none’ and ‘very high’ respectively. The panelists were asked to mark the perceived intensity of each attribute listed on the scorecard by drawing a vertical line on the line scale and writing the code number. The panelists were also asked to indicate the overall quality of the products, on an intensity scale which was anchored at very poor, fair and very good to assess the liking or preference of extruded snacks. The scores for each attribute for a given sample were tabulated, representing the judgment of individual panelists.

Finally, mean value was taken for each attribute of a sample, representing the panel’s verdict about the sensory quality of the product. The data was statistically analyzed and represented graphically as ‘Sensory Profile’.

**Shelf life studies**

Sensory analysis of extruded snack stored under three different conditions namely, refrigerated, ambient (27°C, 65%RH) and accelerated (37°C, 92%RH) was carried out by trained panel. Initial samples as well as samples stored up to 60 days were evaluated for their sensory quality at 30 days intervals using the method of QDA. Refrigerated sample was served as control. In order to trace the changes in quality of the products during storage, specific terminologies such as texture, flavour intensity, spicy, lingering flavour, salt, sweet, sour and lingering taste were used in the evaluation of the products. Each panelist was briefed about the evaluation and samples were served one by one. The findings in the score cards were subject to statistical analyses.

**Instrumental analysis**

Instrumental analysis was carried out for initial as well as stored samples of each flavour of extruded snacks. Change in aroma and texture is recognized by Electronic Nose and Texture Analyzer respectively.

**Electronic Nose (E-Nose)**

Five samples of extruded snacks viz. S1, S2, S3, S4 and S5 were subject to E-Nose analysis (Alpha Fox 3000). Initial samples and samples stored under two different conditions (ambient and accelerated) were taken up for aroma analysis with an interval of 30 days. Snack samples of different flavours were weighed accurately 1 g in a screw capped sample bottle (150 ml capacity) provided by manufacturer. The analysis was conducted as a function of volatile molecules over time under the following conditions.
Electronic Nose with 12 metal oxide semi conducting sensors (6 doped and 6 undoped)

- **Acquisition Time**: 120s
- **Acquisition Period**: 0.05s
- **Delay**: 100s
- **Start Injection**: 50s
- **Injection Time**: 60s
- **Head Space Generation Time**: 100s
- **Zero Air Flow**: 150 ml/min

**Texture analysis**

Texture analysis of extruded snack samples were measured using Texture Analyzer (Stable Micro System, UK) compression method was used to analyze the samples, which simulates the chewing action of jaws. Constant cross head speed of 100 mm per sec was used. The maximum force (N) from the maximum height of the force peak indicates the maximum resistance offered by the product during compression showing a major fracture on the material (Bourne, 2002).

- **Crosshead speed**: 100 mm/sec
- **Compression**: 80% of sample height
- **Probe diameter**: 50 mm
- **Load cell**: 50 Kg

Five pieces of almost uniform in length of 1 inch were taken from each flavour sample and the maximum force required to compress the sample to 80% of the total height was recorded and the average (Mean ± SD) of 5 replicates was reported in Newton. The peak force was calculated by plotting a graph between force (N) and time (s) and represented graphically as force deformation curve.

**Statistical analysis of data**

Mean scores for the attributes were calculated and graphs were plotted. Significance of difference among the attributes and samples can be established by Duncan's Multiple Range Test (DMRT) (Duncan, 1955). Data was analysed using statistical software (Statistica V 5.5 from Statsoft, Tulsa, Ok, USA).

**RESULTS AND DISCUSSION**

Five extruded snacks Viz, S₁, S₂, S₃, S₄ and S₅ were subject to quality evaluation and storage study. All the five samples had similar ingredient composition and they were also processed in similar manner. The variation in their quality was only due to the differences in the flavour ingredients used in their preparation.

**Chemical analysis**

Moisture, Fat, FFA and PV of procured snacks were estimated (Table 2). Moisture content was found to range from 1.4 to 2.5%. Normally crisp snacks have the moisture content below 3% and above this value the product loses its crispness. In this case, all the samples had moisture content within the upper limit, indicating their crisp texture. Also increase in moisture content may affect the puffing of the extruded snack (Lee et al, 2000), optimum moisture content has made this product more crisp and puffy. Lowest fat content was in sample S₁ (31.7%) and highest was in sample S₅ (38.2%). The nutritional information given on the package showed that the approximate fat content is 35.7%. However, the analysis had shown that fat content varies considerably. This could be due to batch variations or variations in frying conditions.

PV and FFA content indicate the quality of oil present in the snack. All the samples had very low PV (0.25-0.66) and FFA content (0.63-0.95%). It indicates that a very good quality refined vegetable oil was used in the preparation of the snacks. During the process of frying, FFA and PV increases gradually and when the frying oil is overused it becomes rich in FFA and PV. However the values given in Table 1 show that the quality of oil is very good. This could be due to proper monitoring of oil quality during deep fat frying particularly with respect to maintaining oil temperature. In the snack food industry, frying oil is regularly filtered to remove the suspended matter coming from the product being fried. Filtration helps in maintaining the colour of the oil, removing suspended particles and controlling the flavour changes. Addition of fresh oil to the deep fat fried oil at regular intervals helps in maintaining low level of FFA and PV. It is evident that with the increase in extrusion temperature PV of the fat will be increased due to rapid oxidation of fat (Rao & Artz, 1989).

**Changes in the quality of snacks during storage**

Packaged snacks were stored at simulated ambient and accelerated conditions. At the end of 30 days of storage, only a very little increase in moisture content was observed in samples kept in both the conditions. However sample S₁ had a moisture content of 4.1% at the end of 30 days under accelerated condition (Table 2). This could be due to defective sealing or pin hole in the packaging material. PV and FFA values did not show any significant increase indicating that the oil quality did not deteriorate during storage. Use of good quality frying oil and presence of antioxidant in the oil could have contributed in maintaining the quality of the sample. Interestingly, in this sets of studies also the fat content of S₁ was the lowest and that S₅ was the highest as in the case of initial sample. The major ingredients in all the five
snacks are of the same; therefore difference in the oil content could be due to variations in the processing conditions. By the end of 60 days of storage there was a slight increase in the moisture content of snacks under accelerated conditions (Table 2), but the values did not cross 3% and hence the product remained fairly crisp. FFA showed a marginal increase in S2 (1.49%) but this level of FFA did not significantly affect the quality of the product. Peroxide values of all the samples were very low (<1.0) which shows that the oil present in the snacks did not undergo significant auto-oxidation.

**Sensory analysis**

Statistical analysis of preference ranking test for flavour revealed that sample S2 was the best among the group followed by S1 and S4. Sample S3 and S5 were inferior compared to sample S1, S2 and S4 (Figure 1). The result of Friedman’s test also showed that there was a significant difference (P≤ 0.05) among the samples. Wilcoxon Mann Whitney U test revealed that samples S2 & S3 and S2 & S4 showed significant difference. All other samples were comparable in terms of flavour preferences.

Table 3 gives the sensory profile of initial samples. Very little difference was found in the texture as given by the mean scores for crispness, which ranged from 7.1-7.8. Flavour intensity was high in S2. Sample S3 had the highest (6.6) spicy note and S1 and S5 had the lowest (4.9). Lingering flavour is an important attribute influencing the acceptability of snack. Lowest lingering flavour (2.5) was given by sample S1 whereas S2 and S4 had the highest lingering flavour (5.8). Saltiness scores were within the narrow range for all the products. Sample S4 had the highest sweetness, and S1 had the lowest (1.4).

Differences in the sweetness scores could be attributed to the composition of flavourings. Flavour composition is also responsible for wide variation in sourness score. Lowest sourness was in S1 and S4 had significantly higher sour note (5.7). Some variations were found in the overall quality scores. S4 and S2 had comparatively highest (7.1 and 7.2) and S5 had the lowest (6.4) overall quality. The high intensity of sourness (5.7) in sample S5 might be the probable reason for its lowered overall quality.

**Changes in sensory quality of snacks during storage**

The samples stored at two conditions viz ambient and accelerated conditions were evaluated for their sensory quality after 30 days and 60 days of storage. Figure 2 shows the mean sensory scores of the samples S1, S2, S3, S4, and S5 at the end of 30 days and 60 days of storage at different conditions.

In the sample S1, the panelists perceived a slight loss of crispness (5.7) for texture and perceptible decrease in flavour intensity after 30 days (5%) and 60 days (4.9) of storage under ambient condition. Loss of spiciness was found to occur over a period of storage. At the end of 60 days the scores for lingering taste was 1.5 which was significantly lower than the score for initial sample (3.2). Though the Overall quality scores declined, the product remained acceptable (> 5.0) at 60 days of storage at both conditions.

Sample S2 showed a similar trend with regard to texture but flavour intensity, spiciness and lingering flavour were not affected during storage for 60 days. Panelists could not perceive any difference in other sensory attributes over 60 days of storage. Hence the overall quality of S2 remained fairly high throughout the storage period.

Mean sensory scores of sample S3 were not significantly affected by the storage condition as well as duration. The panelists were not able to find significant difference in texture, flavour intensity and taste attributes. Spicy note was found to decrease in intensity along with lingering flavour and lingering taste. But these changes did not influence the overall quality which remained in the range of 6.4 to 6.7 throughout the storage period.

In sample S4, intensity of lingering taste was very high (around 4.5), both initially and also at the end of 60 days of storage. Textural changes were not significant but flavour intensity and spicy note decreased. Panelists gave the lowest overall quality score (5.8) to the sample stored for 60 days under accelerated condition. Overall quality of 5.0 shows that the sample is fairly acceptable.

### Table 2. Chemical analysis of initial samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture (%)</th>
<th>Fat (%)</th>
<th>PV (meqO₂)</th>
<th>FFA (as % Oleic acid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>2.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.75&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S2</td>
<td>2.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>37.0&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.95&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S3</td>
<td>2.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>35.6&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.66&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.87&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S4</td>
<td>1.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>37.9&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.56&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.78&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S5</td>
<td>2.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>38.2&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.39&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.63&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means in the same column with different letters differ significantly (p<0.05) (n=3)  
PV-Peroxide value; FFA-Free Fatty Acid; meqO₂-miequivalent oxygen; S1— Masala flavour; S2— Chilli flavour; S3— Pudina flavour; S4— Tomato flavour; S5— Spicy flavour
Table 3. Chemical analysis of snack stored for 30 and 60 days.

<table>
<thead>
<tr>
<th>Storage</th>
<th>Parameters</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MOISTURE (%)</td>
<td>AMB 4.1±0.1</td>
<td>ACC 4.1±0.1</td>
<td>AMB 4.1±0.1</td>
<td>ACC 4.1±0.1</td>
<td>AMB 4.1±0.1</td>
</tr>
<tr>
<td>30 days</td>
<td>FAT (%)</td>
<td>37.2±0.1</td>
<td>36.7±0.1</td>
<td>36.7±0.1</td>
<td>36.7±0.1</td>
<td>36.7±0.1</td>
</tr>
<tr>
<td></td>
<td>PV(meqO2)</td>
<td>0.4±0.01</td>
<td>0.4±0.01</td>
<td>0.4±0.01</td>
<td>0.4±0.01</td>
<td>0.4±0.01</td>
</tr>
<tr>
<td></td>
<td>FFA (as % Oleic acid)</td>
<td>0.8±0.05</td>
<td>0.8±0.05</td>
<td>0.8±0.05</td>
<td>0.8±0.05</td>
<td>0.8±0.05</td>
</tr>
<tr>
<td>60 days</td>
<td>MOISTURE (%)</td>
<td>3.1±0.2</td>
<td>3.1±0.2</td>
<td>3.1±0.2</td>
<td>3.1±0.2</td>
<td>3.1±0.2</td>
</tr>
<tr>
<td></td>
<td>FAT (%)</td>
<td>36.9±0.5</td>
<td>36.9±0.5</td>
<td>36.9±0.5</td>
<td>36.9±0.5</td>
<td>36.9±0.5</td>
</tr>
<tr>
<td></td>
<td>PV(meqO2)</td>
<td>0.5±0.02</td>
<td>0.5±0.02</td>
<td>0.5±0.02</td>
<td>0.5±0.02</td>
<td>0.5±0.02</td>
</tr>
<tr>
<td></td>
<td>FFA (as % Oleic acid)</td>
<td>0.8±0.02</td>
<td>0.8±0.02</td>
<td>0.8±0.02</td>
<td>0.8±0.02</td>
<td>0.8±0.02</td>
</tr>
</tbody>
</table>

Means in the same row for different samples with different letters differ significantly (p<0.05) (n=10); Mean in the same row with no letters did not differ significantly.

PV-Peroxide value; FFA-Free Fatty Acid; meqO2-mliequivalent oxygen; AMB-Ambient condition, ACC-Accelerated condition; S1 – Masala flavour; S2 – Chilli flavour; S3 – Pudina flavour; S4 – Tomato flavour; S5 – Spicy flavour.
Figure 2. Sensory profile of Extruded Snack (Stored-Ambient and Accelerated conditions). 
S1 – Masala flavour; S2 – Chilli flavour; S3 – Pudina flavour; S4 – Tomato flavour; S5 – Spicy flavour

and any score above 5.0 indicates that the product is acceptable.

A slight increase in flavour intensity was perceived by the panelist during the storage of sample S5. The
Figure 3. Typical Force Deformation Curve of Initial Sample
$S_1$— Masala flavour; $S_2$— Chilli flavour; $S_3$— Pudina flavour; $S_4$— Tomato flavour; $S_5$— Spicy flavour

Table 4. Sensory Mean scores of initial sample.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean Scores</th>
<th>Flavour Intensity</th>
<th>Spicy</th>
<th>Lingered Flavour</th>
<th>Salt</th>
<th>Sweet</th>
<th>Sour</th>
<th>Lingered Taste</th>
<th>Overall Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>7.1±1.1a</td>
<td>6.0±0.8a</td>
<td>4.9±0.1a</td>
<td>2.5±0.99</td>
<td>4.6±0.8ab</td>
<td>1.4±0.5a</td>
<td>2.4±0.7a</td>
<td>3.2±0.5a</td>
<td>7.1±0.7a</td>
</tr>
<tr>
<td>S2</td>
<td>7.4±0.5a</td>
<td>6.2±1.7a</td>
<td>5.2±0.5a</td>
<td>3.4±0.8a</td>
<td>4.9±0.5a</td>
<td>1.6±1.2a</td>
<td>2.9±1.1a</td>
<td>3.1±0.4a</td>
<td>7.2±0.8a</td>
</tr>
<tr>
<td>S3</td>
<td>7.3±0.1a</td>
<td>6.3±1.5a</td>
<td>6.6±0.4c</td>
<td>5.8±0.5a</td>
<td>4.4±0.8c</td>
<td>2.0±1.5bc</td>
<td>4.0±0.5c</td>
<td>5.3±0.7c</td>
<td>6.7±0.5a</td>
</tr>
<tr>
<td>S4</td>
<td>7.8±0.1c</td>
<td>7.1±0.5a</td>
<td>5.3±0.3ab</td>
<td>5.8±1.5a</td>
<td>4.2±1.1c</td>
<td>2.8±1.9bc</td>
<td>4.9±0.7c</td>
<td>4.9±1.1c</td>
<td>6.7±0.7c</td>
</tr>
<tr>
<td>S5</td>
<td>7.5±0.1c</td>
<td>6.0±0.5a</td>
<td>4.9±0.8a</td>
<td>5.3±1.7c</td>
<td>4.9±1.7c</td>
<td>2.2±0.9c</td>
<td>5.7±0.01c</td>
<td>5.2±0.1c</td>
<td>6.4±0.7c</td>
</tr>
</tbody>
</table>

Means in the same column with different letters differ significantly ($p<0.05$) ($n=10$)

S1— Masala flavour; S2— Chilli flavour; S3— Pudina flavour; S4— Tomato flavour; S5— Spicy flavour

composition of flavouring formulation might have enhanced its flavour during storage. Similarly spicy note was also slightly higher in stored sample, which resulted in increase in the mean score for lingering flavour. There was a gradual decrease in the overall quality which is reflected in the drop in the score from 6.4 to 5.9 at ambient and 5.8 at accelerated condition for 60 days of storage.

On the whole the results showed that all the five products retained their sensory quality to a great extent and remained acceptable during the 60 days of storage. Interestingly, even under severe conditions of 37°C and 92% RH, the products did not show significant deterioration in their sensory quality and were acceptable.

Changes in the texture of snacks during storage

The peak force was calculated by plotting a graph between force (N) and time (s). The typical Force-Deformation curve of initial sample for all flavours was shown in Figure 3. Total height was recorded and the average (Mean ± SD) of 5 replicates was reported in Newtons (Table 4). It can be seen that the deformation curves have one major peak and many minor peaks. As the products are of low density and have many hollow spaces, minor peaks were seen in the early stage of compression. These peaks represent the crunchiness of the snacks. On the other hand, the major peaks represent the overall hardness of the products. Figure 3 showed that $S_5$ required the lowest force indicating more
**Figure 4.** E-Nose pattern matching of commercial extruded snacks.
S1 – Masala flavour; S2 – Chilli flavour; S3 – Pudina flavour; S4 – Tomato flavour; S5 – Spicy flavour
MM1: Initial, MM2: Ambient (30 days), MM3: Accelerated (30 days), MM4: Ambient (60 days), MM5: Accelerated (60 days) of S1
CC1: Initial, CC2: Ambient (30 days), CC3: Accelerated (30 days), CC4: Ambient (60 days), CC5: Accelerated (60 days) of S2
GC1: Initial, GC2: Ambient (30 days), GC3: Accelerated (30 days), GC4: Ambient (60 days), GC5: Accelerated (60 days) of S3
NT1: Initial, NT2: Ambient (30 days), NT3: Accelerated (30 days), NT4: Ambient (60 days), NT5: Accelerated (60 days) of S4
TH1: Initial, TH2: Ambient (30 days), TH3: Accelerated (30 days), TH4: Ambient (60 days), TH5: Accelerated (60 days) of S5

**Table 5.** Changes in the texture of snacks on storage for 60 days.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Force (N)</th>
<th>60 days storage</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Refrigerated</td>
<td>Ambient</td>
<td>Accelerated</td>
</tr>
<tr>
<td>S1</td>
<td>34.32 ±4.84&quot;</td>
<td>33.35± 4.46&quot;</td>
<td>31.59 ±4.47&quot;</td>
<td>36.76 ±5.96&quot;</td>
</tr>
<tr>
<td>S2</td>
<td>34.24 ±6.42&quot;</td>
<td>34.22 ±6.30&quot;</td>
<td>29.54 ±7.23&quot;</td>
<td>34.05 ±1.60&quot;</td>
</tr>
<tr>
<td>S3</td>
<td>31.30 ±8.33&quot;</td>
<td>32.3 ±9.33&quot;</td>
<td>35.32 ±5.05&quot;</td>
<td>36.07 ±5.36&quot;</td>
</tr>
<tr>
<td>S4</td>
<td>35.58 ±2.80&quot;</td>
<td>34.8 ±2.60&quot;</td>
<td>26.51 ±5.96&quot;</td>
<td>37.49 ±9.08&quot;</td>
</tr>
<tr>
<td>S5</td>
<td>24.65±0.32&quot;</td>
<td>24.4 ±3.30&quot;</td>
<td>28.02 ±1.24&quot;</td>
<td>29.89±6.09&quot;</td>
</tr>
</tbody>
</table>

Means in the same column with different letters differ significantly (p≤0.05) (n=5)
S1 – Masala flavour; S2 – Chilli flavour; S3 – Pudina flavour; S4 – Tomato flavour; S5 – Spicy flavour
of crispness and less of hardness. $S_1$ and $S_4$ require the highest force indicative of harder texture. At the end of 30 days, samples stored under ambient and accelerated condition did not show any difference in peak force. Hence the peak force data is given for the samples of 60 days storage. It was also observed that the product strands were irregular in shape and size with more aerated texture. At the end of 60 days, samples showed a significant difference in peak force in ambient and accelerated conditions.

Changes in E-Nose aroma pattern of a snack during storage

Samples of extruded snacks (S1 to S5) were also subject to aroma analysis using E-Nose. Data generated by E-Nose was statistically analyzed to obtain aroma pattern of snack samples. Aroma pattern of initial and stored samples are given in Figure 3. In sample $S_1$ different quadrants indicated discrimination in aroma pattern (Figure 4-S1).

For sample $S_2$, positioning of aroma pattern showed that initial and stored samples were close to each other (Figure 4-S2) and differences in their aroma patterns were not significant. In the case of $S_3$ aroma pattern of initial sample was slightly away from those of stored sample. This showed that aroma of initial sample could be segregated from the aroma of stored sample (Figure 4-S3). No such segregation was noticed in the case of $S_4$ (Figure 4-S4). Positioning of aroma pattern was random and hence did not reveal any conclusive information. Changes in aroma pattern of $S_5$ were similar to changes in the aroma pattern of $S_3$. Initial samples were placed away from the stored samples (Figure 4-S5) showing segregation on the basis of aroma.

It may be noted that E-nose provided an overall picture of the aroma. Only the volatiles present in the product were absorbed by the sensors of E-Nose and changes in the electrical property of the sensor caused by adsorption were given as responses. E-nose does only partial analysis of flavour because non-volatiles which contribute to the flavour are not considered. Only the volatiles present in the headspace of the sample taken in a closed container are responsible for generating E-nose aroma pattern.

Conclusion

From the present study, it can be concluded that variations in the sensory quality of one type of snack having different flavourings can be traced by adopting suitable sensory evaluation techniques. Consumer preference of flavours can be effectively and quickly determined with the help of preference ranking test. Quantitative Descriptive Analysis by the trained panel provides detailed information on various sensory attributes of a product. This method is helpful in tracing the changes in sensory quality of a product during storage and it also helps in judging its overall quality. Further in addition to the above sensory analysis, Electronic Nose could be used to clearly discriminate the different aroma profile of extruded snack varieties.

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