Paneer tikka, an exotic kebab of Indian cottage cheese is highly rich in proteins, vitamins, minerals, fibre content, sulphur compounds, and laxative in nature. The shelf life of paneer tikka is hardly one day at room temperature and it requires five hours for its preparation. In order to enhance shelf life, the product was vacuum packed in two high barrier packages, viz., LLD/BA*/Nylon-6/BA/LDPE (110 , *binding agent) and metallized polyester/LDPE (20/75 ) along with LDPE (100 ) as control, and stored at 3 ± 1°C. The effect of different packages was observed for changes in chemical, microbial and sensory quality of vacuum packed paneer tikka samples at 0, 10, 20, 30 and 40 day(s). Results indicated that both the high barrier packages significantly inhibited the lipid oxidation, proteolysis and acidity development of vacuum packed paneer tikka. Among the different packages studied samples packed in nylon based high barrier package had minimum microbial count during storage. Sensory analysis showed that control samples had a limited shelf life of 20 days, while a significant increase of 20 days (200%) was obtained for the samples packed in high barrier packages.

Keywords: Paneer tikka, vacuum packaging, shelf life

INTRODUCTION

Paneer tikka, a popular dish for vegetarians, is a tongue tingling favourite of Indian gourmets. Paneer tikka is an exotic kebab of Indian cottage cheese (Kalra and Gupta, 2006). It is extensively used as fast-food during get-togethers, marriage parties, birthday parties, and also in restaurants. It is highly rich in proteins, fat, vitamins, minerals, fibre, sulphur compounds, and is laxative in nature (Goyal et al., 2010). Paneer, which forms base for a variety of culinary dishes including paneer tikka, is an important acid coagulated indigenous variety of soft cheese and tikka refers to general South Asian term meaning marinated barbequed food. Tikka means small pieces of meat or poultry marinated in yoghurt and tandoori spice mix, grilled or roasted and served with Indian bread and salad (Sinclair 2004).

The low shelf life of paneer tikka is mainly due to microbial and physicochemical changes (Ahuja and Goyal, 2011). Vacuum packaging of food product is meant to retard or completely check the oxidative reactions and inhibit the microbial growth by eliminating oxygen. Vacuum packaging extends the normal shelf life of food products by two to three times (Andress, 2006). Hence, effect of vacuum packaging and refrigeration storage was studied to observe the changes in quality and shelf life of product under refrigerated conditions.

MATERIALS AND METHODS

Preparation of paneer tikka

The base material for preparation of paneer tikka, i.e. paneer, was prepared by method as described by Shrivastava and Goyal (2009). Curd was prepared from standardized buffalo milk (6% fat) as per the method suggested by De (1980) employing previously activated starter culture (NCDC-167) procured from National Collection of Dairy Cultures, National Dairy Research Institute, Karnal, India. Butter and cream were collected from the Experimental Dairy of National Dairy Research Institute, Karnal. The fresh vegetables namely tomatoes, onion, garlic and ginger of superior quality, spices such as red chilli powder, chicken masala, garam masala of a famous Indian brand, common salt, black salt and amchur powder (from unripened mango) were procured from the local market. Microwave oven having power output of 900 W with internal...
dimensions of 36 x 37 x 23 cm³ and 32 L capacity from Samsung, South Korea; Model Bio ceramic CE118KF was used for baking paneer tikka.

For preparing marinade, required for making paneer tikka from 1 kg of paneer, onion (50 g), ginger (15 g) and garlic (8 g) were peeled off, washed with water and cut into small pieces. Tomatoes (50 g) were cut into two halves and pedicels were removed. Powdered spices (chicken masala 13 g, garam masala 7 g, red chilli powder 10 g and amchur powder 10 g) and salt (table salt 15 g and black salt 5 g) were blended thoroughly. Onion, ginger, garlic and tomatoes along with powdered spice blend were ground in a mixer. Forty grams out of 1 kg curd was added prior to grinding in order to prevent jamming of mixer. Well mixed and ground spice blend was added to rest of the curd (960 g) along with cream (50 ml) and mixed with a ladle. Paneer was cut into approximate sizes of 3.5 x 2.5 x 2.5 cm³ by using a clean and sterile knife. Paneer chunks (small paneer blocks) were immersed in marinade and kept under refrigeration at 3 ± 1°C for 4 - 5 h. The marinated pieces of paneer chunks were skewered on stainless steel skewers (3.5 mm diameter), previously brushed with butter. Skewers were inserted through the centre of paneer chunks from the 2.5 x 2.5 cm² side. The skewers containing marinated paneer chunks were placed horizontally over a stand in oven. The baking of marinated paneer chunks was achieved in a preheated (10 min at 200°C) microwave oven at 200°C for 22 - 24 min in convection mode. After baking, the paneer tikka pieces were removed from skewers on a previously cleaned tray with the help of a flat spatula.

Packaging and storage

The freshly prepared and cooled paneer tikka samples (250 g) were packed under vacuum in two different high barrier sterilized packages, namely LLD/BA/Nylon-6/BA/LDPE and metallized polyester/LDPE along with LDPE packages as control. Packaging materials were sterilized in the manner as described by Kumar and Srinivasan (1982). Packaging under vacuum was accomplished by using a vacuum chamber machine (Model: Indvac; Make: Saurabh Engineers, Ahmedabad, India), after establishing a vacuum of 0.70 kPa. The packaged samples were then stored at 3 ± 1°C.

Proximate analysis

Moisture content and total fat were estimated by using the method of IS:SP:18 (Part XI 1981). Total protein and ash content of samples were determined by AOAC (1990) method. The salt content of samples was determined following the procedure adopted by Alam (2004). Carbohydrates were estimated by difference method, and the food energy value was calculated by the method recommended by Mullan (2006).

Chemical quality evaluation

The paneer tikka samples were analysed to determine moisture (IS:SP:18 Part XI 1981), titratable acidity (AOAC 1990), pH (Rai et al., 2008), free fatty acids content in terms of oleic acid (Thomas et al., 1954) and protein breakdown in terms of tyrosine content (Hull, 1947). The samples stored at 3±1°C were tempered at 15.5°C for 1 h before analysis. Water activity determination of samples was carried out by using Aqua Lab water activity meter (series 3TE, Decagon Devices Inc., Washington, USA).

Microbial quality evaluation

Total plate count, psychrotrophic count, yeast and moulds count and coliform count of samples were determined by following APHA (1992) procedures.

Sensory quality evaluation

The packed samples were evaluated organoleptically for sensory attributes by a trained panel for colour and appearance, flavour, body & texture, and overall acceptability. Before presenting the samples to Judges, the stored test samples were reheated for 5 min in a preheated (200°C/10 min) microwave oven (convection mode). The samples were evaluated using 5-point Hedonic Scale. A score of 5 represented excellent; 4, very good; 3, good; 2, fair; and 1, poor.

Statistical analysis

Each experiment was conducted in three separate trials. Results represent the means with standard deviation. The data obtained during analysis were subjected to two way analysis of variance (ANOVA) with types of packages and storage days intervals as main effect (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

Proximate Analysis

Proximate analysis results of freshly prepared
Effects of different packages on moisture content and water activity (aw)

Vacuum packed paneer tikka samples, when stored at 3 ± 1°C for 30 days showed highest moisture loss of 1.9% by decreasing from its initial value (%) of 46.8 ± 0.09 to 45.9 ± 0.06 for the samples packed in LDPE (P1) followed by moisture loss of 0.42% and 0.85%, respectively in LLD/BA/Nylon-6/BA/LDPE (P2) and metallized polyester/LDPE (P3) (Fig. 1). On further storage up to 40 days, for the samples packed in P2 and P3 the moisture content (%) decreased to 46.5 ± 0.03 and 46.4 ± 0.03 suggesting that the minimum decrease was for the samples packed in P2 followed by P3. Verma et al., (2007) reported comparatively lower moisture loss in modified atmosphere packed paneer tikka when stored for 21 days at 7 ± 1°C. Water activity (aw) represents the water availability in foodstuff, the changes in aw of paneer tikka samples during storage corresponded to the moisture loss. The aw of vacuum packed paneer tikka samples decreased from 0.98 ± 0.00 to 0.97 ± 0.00 in all the three packages P1, P2 and P3 at the end of 30 days storage (Figure 1a). Similar (Singh et al., 2010) trends for decrease in water activity have been reported during storage of modified atmosphere packed ready to bake pizza samples.

Effects of different packages on pH and titratable acidity

Significant differences (?<0.05) towards the changes in pH were observed due to storage days intervals and types of packages. The pH of samples in the packages P1, P2 and P3 decreased from 5.42 ± 0.03 to 5.22 ± 0.02 (P1), 5.29 ± 0.02 (P2) and 5.25 ± 0.01 (P3) after 30 days of storage, suggesting that the maximum decrease was for the samples packed in P1, and minimum was in P2 (Table 1). Verma et al., (2007) also reported consistent decrease in pH during storage of paneer tikka. The decrease in pH might be due to lactic acid production by spoilage organisms (Daifas et al., 1999). The titratable acidity (% lactic acid) of 0.98 ± 0.02 (day 0) of vacuum packed paneer tikka increased to 1.16 ± 0.01, 1.08 ± 0.01 and 1.08 ± 0.01, respectively in P1, P2 and P3 after 30 days of storage indicating that the product packed in P2 and P3 developed minimum acidity, while the samples packed in P1 had maximum. The results were in agreement with the findings of Verma et al., (2007) who observed increase in TA of modified atmosphere

Table 1: Proximate analysis (%) of fresh paneer tikka

<table>
<thead>
<tr>
<th>Composition</th>
<th>Proportion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>46.8±0.09</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>19.6±0.77</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>27.9±0.40</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>2.8±0.06</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>2.6±0.13</td>
</tr>
<tr>
<td>Salt (%)</td>
<td>1.4±0.13</td>
</tr>
<tr>
<td>Food Energy value (kcal/100g)</td>
<td>385.18±8.68</td>
</tr>
</tbody>
</table>

*Each value is mean ±SD of 3 trials

Figure 1. Chemical changes: water activity aw (a); free fatty acids (per cent oleic acid) (b); tyrosine content (mg/100 g) (c); of vacuum packed paneer tikka samples packed in three different packages and stored at 3 ± 1°C. Each point is the mean ± SE of three independent trials.
packed paneer tikka during storage at 7 ± 1°C. In case of samples stored for 40 days, increase in TA had been lower for samples packed in P2 than P3.

Effects of different packages on free fatty acids and tyrosine content

Free fatty acids (FFA) are often used as indicators of lipolysis (Kondyli, 2002). The initial FFA content of 0.16 ± 0.00 (% oleic acid) of vacuum packed paneer tikka samples increased to 0.31 ± 0.01 in P1, 0.30 ± 0.01 in P2 and 0.29 ± 0.01 in P3 after 30 days of storage, revealing more increase in FFA for the samples packed in P1 (48.38% increase) compared to P2 (45.16% increase) and P3 (41.93% increase). On further storage up to 40 days, the FFA values increased to 0.31 ± 0.01 in P2 and P3, thus establishing lower fat cleavage in P2 and P3 (Figure 1b). The tyrosine content, an index for proteolysis increased from 37.21 ± 2.40 (day 0) to 59.08 ± 2.72, 47.41 ± 4.14, and 48.19 ± 5.16 (mg/100 g) in P1, P2 and P3, respectively, at the end of 30 days storage (Figure 1c). Among the 3 types of packages, the maximum breakdown of protein was observed in the product packed in P1. The data concerning tyrosine content revealed that the duration of storage and types of packages significantly (P<0.05) influenced the tyrosine content of vacuum packed paneer tikka. On correlating FFA and tyrosine content with results from sensory evaluation, it was observed that the samples with higher FFA values and tyrosine content had lower flavour and overall acceptability scores (Table 2).

Effects of different packages on microbial quality

The total plate count (TPC) of 3.38 ± 0.09 (day 0) increased to 3.63 ± 0.06 in P1, 3.45 ± 0.11 in P2 and 3.60 ± 0.10 in P3 (day 30). On the further storage up to 40 days TPC increased to 3.50 ± 0.04 and 3.57 ± 0.07, respectively in P2 and P3. Similar results have been reported by Verma (2005) for modified atmosphere packed paneer tikka samples at 7±1°C. The ANOVA of the data concerning TPC established significant (P<0.05) influence of types of packages on TPC.

Psychrotrophic count (log cfu/g) at day 0 was 1.49 ± 0.20, which increased to 2.55 ± 0.13 in P1, 2.31 ± 0.22 in P2, and 2.39 ± 0.11 in P3 when stored for 30 days. Verma (2005) reported slightly lower values for initial psychrotrophic count of paneer tikka, but growth rate was comparatively higher, which might be due to the difference in storage temperature. Significant (P<0.05) differences towards the increase in yeast and mould (Y and M) count were observed due to types of packages and storage days intervals. The initial Y and M count (log cfu/g) increased from 1.62 ± 0.15 to 2.80 ± 0.08, 2.18 ± 0.09 and 2.20 ± 0.09 in P1, P2 and P3, respectively. Similar trends for the rise in Y and M have been reported by Verma (2005). The coliform count in freshly prepared panner tikka samples and vacuum packed samples stored at 3 ± 1°C was found nil in the second dilution (10-2) throughout the storage period. However,
these results are in contrary with the findings of Verma (2005) who reported higher values for coliform count in modified atmosphere packed paneer tikka samples when stored at 7±1°C for 21 days. The absence of coliform in our samples is most likely due to the difference in recipe of paneer tikka, such as absence of vegetables during baking and packing and increased quantity of spices such as garlic in the recipe. Leuchner and Zamparini (2002) reported bacteriostatic effect of Garlic (1% w/v) towards E. coli 0157, in mayonnaise. Study carried out by Al-Jedah et al., (2000) also suggested the bacteriostatic action of combined spices, including cumin, coriander, mustard, black pepper and lemon on E. coli count in fish sauce.

Effects of different packages on sensory quality
The results of the sensory evaluation of paneer tikka samples are presented in Table 2. Scores for colour and appearance, body & texture, and flavour showed a similar pattern of decreasing acceptability with increase in storage period. The initial overall acceptability score of 4.3 decreased to 1.7 for the samples packed in P1 at the end of 30 days storage. Paneer tikka samples packed in P1 remained acceptable only up to 20 days. However, the samples packed in P2 and P3 remained acceptable up to 40 days with overall acceptability score of 3.8 ± 0.29 and 3.7 ± 0.29, respectively.

CONCLUSIONS
In order to determine the shelf life of paneer tikka, the samples were vacuum packed in two high barrier packages (LLD/BA/Nylon-6/BA/LDPE and metallized polyester/LDPE) along with LDPE package as control and stored for various time intervals at 3±1°C. The data obtained for the overall acceptability were used to establish the product’s shelf life. The samples packed in LDPE remained acceptable only up to 20 days, whereas high barrier packages were found effective to enhance the shelf life of product up to 40 days (a 200 % increase). Out of 3 packages studied, LLDPE/BA/Nylon-6/BA/LDPE was most effective in controlling the physicochemical, microbial and sensory changes during storage, thus proving the best for vacuum packaging and refrigerated storage (3 ± 1°C) of paneer tikka for 40 days.

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