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SHORT COMMUNICATION

Combined effect of vacuum packaging and refrigerated storage on the chemical quality of *paneer tikka*

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Abstract *Paneer tikka*, a popular dish for vegetarians, is a tongue tingling favourite of Indian gourmets. It is a perishable commodity which requires more than five hours for its preparation. The shelf life of *paneer tikka* is hardly one day at room temperature which impedes its proper marketing. In order to enhance the shelf life of *paneer tikka*, the product was vacuum packed in two high barrier packages, viz., LLDPE*/BA†/Nylon-6/BA/LDPE‡ (110 μ, *linear low density polyethylene, †binding agent, ‡low density polyethylene) and metallized polyester/LDPE (20/75 μ) along with LDPE (100 μ) as control, and stored at 3±1 °C. The stored samples were evaluated at 0, 10, 20, 30 and 40 day(s) for changes in chemical characteristics, namely moisture, pH, titratable acidity, free fatty acids content, tyrosine content and water activity. The analysis of variance of the data revealed that type of packages had significant influence on all the above parameters excluding water activity during storage of *paneer tikka*.

Keywords Paneer tikka · Chemical quality · Vacuum packaging

Introduction

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 and fat, and also contains 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 storage was studied for the changes in chemical quality of *paneer tikka* stored at 3±1 °C.

Materials and methods

In the present study, *paneer*, which is base material for preparation of *paneer tikka* 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,

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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* (ingredients: coriander, chillies, cumin, turmeric, fenugreek leaves, salt, black pepper, dry ginger, mustard, bay leaf, pulse, cloves, nutmeg, caraway, cinnamon, cardamom seeds, mace, asafoetida), *garam masala* (ingredients: cumin, black pepper, coriander, cardamom seeds, cloves, nutmeg, cinnamon, dry ginger, bay leaf, caraway, mace) 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 36×37×23 cm^3 and 32 L capacity from Samsung, South Korea; Model Bio ceramic CE118KF was used for baking *paneer tikka*.

Preparation of marinade 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) after washing with water 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 thoroughly with a ladle. The prepared marinade was kept under refrigeration at 3±1 °C.

Marination Blocks of *paneer* were cut into approximate size of 3.5×2.5×2.5 cm^3 by using a clean and sterile knife. *Paneer* chunks (small *paneer* blocks) were immersed in marinade and mixed with the help of ladle and kept under refrigeration at 3±1 °C for 4–5 h for marination. Precautions were taken to prevent the breakage of *paneer* chunks inside marinade during mixing. Mixing was essentially done to obtain uniform coating of marinade on *paneer* chunks.

Baking of paneer tikka The marinated pieces of *paneer* chunks were skewed on stainless steel skewers (3.5 mm diameter), previously brushed with butter (to avoid stickiness). Skewers were inserted through the centre of *paneer* chunks from the 2.5×2.5 cm^2 side. 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/oven mode. The skewers containing marinated *paneer* chunks were placed horizontally over a stand in oven keeping a tray beneath the stand for collecting the drips of marinade during baking. 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 LLDPE/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.

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). Water activity determination of *paneer tikka* samples was carried out by using Aqua Lab water activity meter (series 3TE, Decagon Devices Inc., Washington, USA). The samples stored at 3±1°C were tempered at 15.5°C for 1 h before analyses.

Statistical analysis Each experiment was conducted in three separate trials. Results represent the means with standard deviations. 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. ANOVA was followed by Fisher's least significant difference test (Snedecor and Cochran 1989) for multiple sample comparison ($\rho<0.05$).

Results and discussion

Moisture content Paneer tikka samples vacuum packed in two high barrier packages along with LDPE, 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 (P_1) followed by moisture loss of 0.42 % and 0.85 %, respectively in LLDPE/BA/Nylon-6/BA/LDPE (P_2) and metallized polyester/LDPE (P_3) (Table 1). On further storage up to 40 days, for the samples packed in P_2 and P_3 the moisture content (%) decreased to 46.5±0.03 and 46.4±0.03 respectively, suggesting that the minimum decrease was for the samples packed in P_2 followed by P_3, in ascending order. Verma et al. (2007) reported comparatively lower moisture loss in modified atmosphere packed *paneer tikka* when stored for 21 days at 7±1 °C. ANOVA of the data concerning

moisture content (Table 2) reveals that, storage intervals and type of packages were found to be have significant ($\rho<0.05$) effect on moisture content. Interaction of storage intervals x types of packages however, was not significant.

Titratable acidity The initial titratable acidity (% lactic acid) of 0.98±0.02 in vacuum packed *paneer tikka* increased to 1.16±0.01, 1.08±0.01 and 1.08±0.01, respectively in P_1, P_2 and P_3 after 30 days of storage (Table 1), indicating that the product packed in P_2 and P_3 developed minimum acidity, while the samples packed in P_1 had maximum. The results were in agreement with the findings of Verma et al. (2007) who observed increase in titratable acidity (TA) of modified atmosphere packed *paneer tikka* during storage at 7±1 °C. In case of samples stored for 40 days, the data indicate that TA had been lower for samples packed in P_2 than P_3. From the viewpoint of development in TA, storage intervals, types of package, interaction of storage intervals x types of packages each individually had significant ($\rho<0.05$) effect (Table 2).

pH The pH of samples in the packages P_1, P_2 and P_3 decreased from 5.42±0.03 to 5.22±0.02 (P_1), 5.29±0.02 (P_2) and 5.25±0.01 (P_3) after 30 days of storage, suggesting that the maximum decrease was for the samples packed in P_1, and minimum was in P_2 (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 pH of samples in packages P_2 and P_3 decreased to 5.27± 0.02 and 5.23±0.01 after 40 days of storage. Significant differences ($\rho<0.05$) towards the changes in pH were found due to storage intervals and types of packages (Table 2).

Free fatty acids The initial free fatty acids (FFA) content of 0.16±0.00 (% oleic acid) of vacuum packed *paneer tikka* samples increased to 0.31±0.01 in P_1, 0.30±0.01 in P_2 and 0.29±0.01 in P_3 after 30 days of storage, revealing more increase in FFA for the samples packed in P_1 (93.75 % increase) compared to P_2 (87.50 % increase) and P_3 (81.25 % increase) (Table 1). On further storage up to 40 days, the FFA values increased to 0.31±0.01 in P_2 and P_3, thus establishing lower fat cleavage in P_2 and P_3. The influence of storage intervals on the FFA values was more significant ($\rho<0.01$) than types of packages ($\rho<0.05$) during storage (Table 2).

Tyrosine content At the end of 30 days storage of vacuum packed *paneer tikka* at 3±1 °C, the initial mean tyrosine

Table 1 Physico-chemical changes in vacuum packed *paneer tikka* during storage 3±1 °C

Characteristics	Type of package	Period of storage (days)				
		0	10	20	30	40
Moisture content (%)	P_1		46.5 ± 0.08^{b}	46.1 ± 0.10^{cA}	45.9 ± 0.06^{cA}	NA
	P_2	46.8 ± 0.09^{a}	46.7 ± 0.10^{a}	46.6 ± 0.04^{aB}	46.6 ± 0.03^{aB}	46.5 ± 0.03^{b}
	P_3		46.7 ± 0.04^{ab}	46.5 ± 0.04^{bcB}	46.4 ± 0.03^{cB}	46.4 ± 0.03^{c}
Titratable acidity (%LA)	P_1		1.07 ± 0.03^{bA}	1.12 ± 0.02^{cA}	1.16 ± 0.01^{dA}	NA
	P_2	0.98 ± 0.02^{a}	1.03 ± 0.01^{bB}	1.06 ± 0.01^{bcB}	1.08 ± 0.01^{cdB}	1.09 ± 0.00^{d}
	P_3		1.03 ± 0.02^{bB}	1.07 ± 0.01^{cB}	1.08 ± 0.01^{cB}	1.11 ± 0.02^{d}
pH	P_1		5.34 ± 0.03^{b}	5.29 ± 0.01^{a}	5.22 ± 0.02^{cA}	NA
	P_2	5.42 ± 0.03^{a}	5.37 ± 0.02^{b}	5.33 ± 0.02^{bc}	5.29 ± 0.02^{cdB}	5.27 ± 0.02^{d}
	P_3		5.36 ± 0.02^{b}	5.31 ± 0.00^{c}	5.25 ± 0.01^{dAB}	5.23 ± 0.01^{d}
FFA (%Oleic acid)	P_1		0.20 ± 0.01^{bA}	0.28 ± 0.01^{cA}	0.31 ± 0.01^{dA}	NA
	P_2	0.16 ± 0.00^{a}	0.18 ± 0.01^{aB}	0.27 ± 0.01^{bA}	0.30 ± 0.01^{cAB}	0.31 ± 0.01^{d}
	P_3		0.17 ± 0.00^{aB}	0.25 ± 0.01^{bB}	0.29 ± 0.01^{cB}	0.31 ± 0.01^{d}
Tyrosine content (mg/100 g)	P_1		49.3 ± 1.55^{bA}	57.7 ± 3.54^{cA}	59.1 ± 2.72^{cA}	NA
	P_2	37.2 ± 2.40^{a}	43.6 ± 3.51^{abAB}	45.5 ± 1.79^{abB}	47.4 ± 4.14^{bB}	47.9 ± 3.04^{b}
	P_3		40.3 ± 2.14^{abB}	45.0 ± 3.60^{abB}	48.2 ± 5.16^{bcB}	54.7 ± 3.87^{c}
Water activity (a_w)	P_1		0.97 ± 0.00^{b}	0.97 ± 0.00^{b}	0.97 ± 0.00^{b}	NA
	P_2	0.98 ± 0.00^{a}	0.98 ± 0.00^{a}	0.98 ± 0.00^{a}	0.97 ± 0.00^{b}	0.97 ± 0.00^{b}
	P_3		0.98 ± 0.00^{a}	0.98 ± 0.00^{a}	0.97 ± 0.00^{b}	0.97 ± 0.00^{b}

P_1: Low density polyethylene (LDPE), P_2: LLDPE*/BA†/Nylon-6/BA/LDPE (* linear low density polyethylene, † binding agent), P_3: Metallized polyester/LDPE, NA: Not analysed (samples spoiled), Means with different superscripts (a, b, c, d) in the same row indicate significant difference (Fisher's LSD test, $\rho<0.05$) from each other. Means with different superscripts (A, B) in a column indicate significant difference (Fisher's LSD test, $\rho<0.05$). Each value is mean±SD of 3 trials

Table 2 Analysis of variance for chemical characteristics of vacuum packed *paneer tikka* stored at 3±1 °C

Source of variation	df	Mean sum of squares					
		Moisture	Titratable Acidity	pH	Free Fatty acids	Tyrosine Content	Water activity
Among Intervals of storage	4	0.125*	0.00842**	0.0148**	0.0130**	119.020**	0.0000621*
Among packages	2	0.153*	0.0026*	0.00152*	0.000380*	81.805*	0.0000333
Error	7	0.0245	0.000344	0.000212	0.0000533	12.884	0.00000952
Interaction [Intervals (0, 10, 20, 30) x Packages]	6	0.0789	0.00115*	0.000656	0.000157	33.780	0.0000333**
Error	24	0.0378	0.000411	0.000847	0.0000681	22.407	0.00000278

* Significant at 5 % level of probability, ** Significant at 1 % level of probability

content (mg/100 g) increased from 37.21±2.40 to 59.08± 2.72, 47.41±4.14, and 48.19±5.16 in P_1, P_2 and P_3, respectively (Table 1). Among the 3 types of packages, the maximum breakdown of protein was observed for the product packed in P_1. On further storage of product for 40 days, the tyrosine content increased to 47.95±3.04 and 54.72±3.87 respectively, in case of samples packed in P_2 and P_3, indicating that the minimum proteolysis occurred in the *paneer tikka* samples packed in P_2. The ANOVA of the data concerning tyrosine content (Table 2) revealed that the duration of storage significantly ($\rho<0.01$) affected the tyrosine content in stored samples of vacuum packed *paneer tikka*. The effect of types of packages was also found to be significant ($\rho<0.05$), while the interaction between intervals of storage and types of packages was not significant.

Water activity The changes in water activity (a_w) of vacuum packed *paneer tikka* samples during storage at 3±1 °C in three different packaging materials are presented in Table 1. After 30 days of storage, initial mean value of 0.98±0.00 was decreased to 0.97±0.00 in all the three packages P_1, P_2 and P_3. Since, water activity represents the water availability in foodstuff, the changes in a_w of *paneer tikka* samples during storage corresponded to the moisture loss during storage. On further storage of the product up to 40 days in P_2 and P_3 no change in a_w was observed. ANOVA of the data concerning a_w (Table 2) revealed that interaction effect of storage intervals x types of packages was highly significant ($\rho<0.01$). Duration of storage also established significant ($\rho<0.01$) influence on the a_w of *paneer tikka* samples. Similar results have been reported (Singh et al. 2010) for changes in water activity during storage of modified atmosphere packed ready to bake pizza samples when stored at 7±1 °C.

Conclusion

Out of 3 packages studied, LLDPE/BA/Nylon-6/BA/LDPE was most effective in controlling the chemical 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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