



## RESEARCH PAPER

# Shelf- life of *Paneer butter* spread using modified atmospheric packaging (MAP) at different storage temperature

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**Abstract :** India is the world's largest producer of milk by volume. Milk is considered to be an appropriate source of valuable macronutrients (fat, protein, lactose) vitamins and micronutrients as minerals which can make it a wholesome food. Food and nutritive value of *Chhana* or *Paneer* is fairly high as it contains almost all the protein present in milk besides quantity of minerals and vitamins. In this research take the four levels of *Paneer*, butter and garden cress seed. the product stored under MAP had the best shelf life of 10 days at 4 °C based on its sensory and physico-chemical evaluation and microbial counts.

**Key Words :** Paneer butter spread, Moisture, Sensory analysis, Microbial count

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## INTRODUCTION

India is the world's largest producer of milk by volume. Milk is considered to be an appropriate source of valuable macronutrients (fat, protein, lactose) vitamins and micronutrients as minerals which can make it a wholesome food. It can serve as an excellent carrier product for extra nutrient and if enriched or fortified it can satisfy the nutritional needs of the people (Krupa *et al.*, 2011). The country accounts for more than 15% of world's total milk production and is also the world's largest consumer of dairy products. Dairying has been regarded as one of the activities that could contribute to alleviating the poverty and unemployment especially in the drought-prone and rain-fed areas. In India, about three-fourth of the population live in rural areas and about 32.7% of the

population are in below poverty line (NSSO, 2011). Therefore, among these people, as well as the large vegetarian segment of the country's population, dairy products provide a critical source of nutrition and animal protein to millions of people in India.

Food and nutritive value of *Chhana* or *Paneer* is fairly high as it contains almost all the protein present in milk besides quantity of minerals and vitamins. It possesses a nutty flavour with slightly sour and sweet taste which makes it palatable to Indian palate. It is an ideal food for expectant and nursing mothers, infants, growing children, adolescents and adults. Being rich source of animal protein, it is a good source of all the essential amino acids to the vegetarian. Its fat content renders the fat soluble vitamins A and D, essential fatty

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acids (linoleic, linolenic and arachidonic acid) and energy. With its high protein and low sugar content, it is highly recommended to the diabetic patients. It has also particular food value for those who possess the problem of milk intolerance. The energy value of cow *Chhana* or *Paneer* ranges from 2866 to 3748 calories per kg and *chhana* or *paneer* also retains appreciable proportion of fat soluble vitamins like A and D (Ray and De, 1954).

Garden cress (*Lepidium sativum* L.) belonging to *Brassicaceae* family is widely grown in India, Europe and USA. It has been used as an important medicinal plant since the *Vedic* era. In *Ayurveda*, it is considered as hot, bitter, galactagogue and aphrodisiac and claimed to prevent *Vata* and *Kapha*. Garden cress seed is good source of essential and non-essential amino acids and they are also used as a novel source of hydrocolloid.

Shelf-life of the product can be increased by changing the environment to which it is exposed and/or the packaging system (Harte and Gray, 1987). The deteriorating agents of the food quality are oxygen contained in the air and microorganisms (bacteria and mold). Oxygen promotes several types of deteriorative reactions in foods including oxidation of fat, browning reactions and pigment oxidation. Oxygen is the key element required for the growth of common spoilage bacteria and fungi. Therefore, to increase the shelf life of foods, the package atmosphere should contain a low concentration of residual oxygen (Sandhya, 2010).

MAP technique can be effectively used to reduce or eliminate the need of chemical preservation while maintaining a desired shelf life for the packaged food product (Fernandez *et al.*, 2000). MAP technique is based on changing the gas combination of the environment in which the product is packed. The gases that are mostly used are carbon dioxide (CO<sub>2</sub>) and nitrogen (N<sub>2</sub>). CO<sub>2</sub> is both fungistatic and bacteriostatic and prevents insect growth in packaged and stored food products.

## MATERIAL AND METHODS

### Cow milk:

Milk was collected daily in morning from dairy farm, and was kept in the refrigerator and was brought to the laboratory for the analysis.

### Butter:

Amul brand butter was obtained from the local market of Varanasi (U.P) India.

### Coagulants:

Analytical grade citric acid was used as coagulant for the preparation of *Paneer butter spread* and it was obtained from the laboratory of Animal Husbandry and Dairying, Banaras Hindu University, Varanasi (U.P) India.

### Salt:

Refined Commercial grade Tata brand salt was used for the preparation of *Paneer butter spread*. It was obtained from the local market of Varanasi (U.P) India.

### Manufacturing of *Paneer butter spread* :

*Paneer butter spread* was manufactured using standardized cow milk (4.2% fat and 9% SNF). Standardized milk was taken in a jacketed vessel and heated to simmering temperature (85-90 °C) with continuous stirring by a wooden ladle in a circular motion with occasional scraping of the heating surface. After 10-15 minutes of boiling, 0.02 percent of citric acid (in the form of solution) was added to the milk for the purpose of formation of granules. Vigorous stirring was performed to obtain good quality product. The intensity of heating was reduced when semi-solid state was reached. Amul butter was added into *Paneer* and was

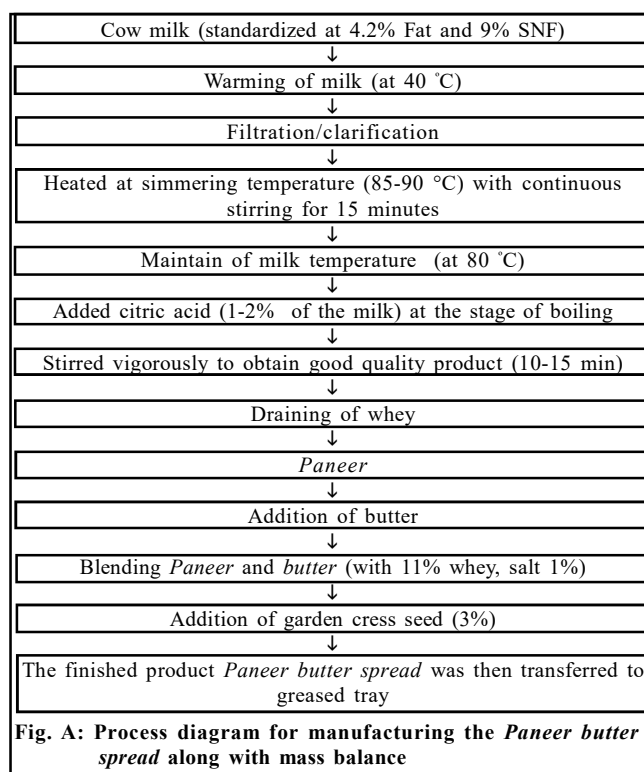


Fig. A: Process diagram for manufacturing the *Paneer butter spread* along with mass balance

thoroughly mixed up. Then Garden cress seed @ 3% and salt @ 1% was added into the *Paneer* and butter mixture at room temperature and was mixed up by using mixer grinder for 5 min. The samples were stored at refrigeration temperature (4 °C, 10 °C, 25 °C) for testing the physico-chemical qualities and its shelf-life quality. The process diagram for manufacturing of *Paneer butter spread*.

#### Levels of factors for optimization of the product:

*Level of Paneer:*

- 100%
- 90%
- 80%
- 70%

*Level of butter :*

- 0%
- 10%
- 20%
- 30%

*Level of garden cress seed :*

- 0%
- 1%
- 2%
- 3%

$T_0$  Control sample :

Replication :

- R1
- R2
- R3

E- Total number of observation=  $12 \times 3 = 36$

Treatment of different level combination of *Paneer* @ 100%, 90%, 80%, 70% and butter @ 0%, 10%, 20%, 30% and garden cress seed @ 0%, 1%, 2%, 3% (by weight).

#### Sensory evaluation :

The sensory analysis of *Paneer butter spread* stored under MAP was carried out by a semi trained panel of 9 judges drawn from staff and students of the Department of Animal Husbandry and Dairying and the Centre of Food Science and Technology at Banaras Hindu University, Varanasi (India). The judges were asked to score for the sensory attributes viz., colour and appearance, flavour, body and texture, sweetness and

overall acceptability, on a 9-point Hedonic scale. And the treatment which got highest hedonic score was selected as the optimized product.

#### Statistical analysis :

Observation related to mean and standard deviation at different temperature and days of the microbial changes (Total plate count, coliform count and yeast and mold count) and sensory profile (flavour, body and texture, colour and appearance and overall acceptability) are calculated analysis of variance technique (ANOVA) and Factorial Complete Randomized Design was applied for detecting the effect of temperature and days simultaneously on moisture content.

## RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

#### Storage of *Paneer butter spread* under MAP :

*Changes in the moisture content :*

Moisture content of any product is a critical parameter in determining the textural and organoleptic parameters of the product. It is evident from Table 1. That the average moisture content of the *Paneer butter spread* samples decreased with increase in the storage period. The moisture content was also affected by the temperature of the storage. It can be seen from Table 2 that the reduction in moisture content was the least in the samples stored at 4 °C as in 0, 5, 10, 15 and 20 days moisture content was  $49.40 \pm 0.46$ ,  $49.19 \pm 0.46$ ,  $48.96 \pm 0.45$ ,  $48.55 \pm 0.37$  and  $47.54 \pm 0.21$  respectively while it was the highest in the samples stored at 25 °C as in 0, 5, 10, 15 and 20 days moisture content was  $48.78 \pm 0.22$ ,  $48.53 \pm 0.47$ ,  $46.99 \pm 0.11$ ,  $45.07 \pm 0.08$  and  $41.37 \pm 0.07$ . The moisture content of the *Paneer butter spread* also varied with packaging conditions.

Several earlier workers experimented on effect of temperature on moisture content. The chemical changes such as moisture loss, HMF, FFA and TBA in *Lal peda* during storage period at 4 and 37 °C were studied. The rate of loss of moisture was found to be higher at temperature of 37 °C than at 4 °C (Jha *et al.*, 2012). The *Brown peda* samples were packed through three different packaging techniques and the chemical changes in all samples were observed. They found the decrease in moisture, pH and water activity of *Brown peda* at 30

°C for 40 days depending upon the packaging materials and packaging techniques which effect the moisture loss during storage (Londhe *et al.*, 2012). Thus, the findings related to the moisture content analysis collaborate with the findings of aforementioned experiments.

### Changes in sensory properties of paneer butter spread under MAP :

The sensory characteristics of *Paneer butter spread* samples were evaluated on the basis of flavor, body and texture, colour and appearance and overall

**Table 1 : Treatment of different level combination of paneer, butter and garden cress seed**

Combination	Paneer butter ratio @ 100:0	Paneer butter ratio @ 90:10	Paneer butter ratio @ 80:20	Paneer butter ratio @ 70:30
Garden cress seed @ 1 %	T <sub>1</sub> 100:0:1 combination of <i>paneer</i> @ 100 %, butter @ 0 % and garden cress seed @ 1 % by weight	T <sub>2</sub> 90:10:1 %combination of <i>paneer</i> @ 90 %, butter @ 10 % and garden cress seed @ 1% by weight	T <sub>3</sub> 80:20:1 combination of <i>paneer</i> @ 80 %, butter @ 20 % and garden cress seed @ 1% by weight	T <sub>4</sub> 70:30:1 combination of <i>paneer</i> @ 70 %, butter @ 30 % and garden cress seed @ 1% by weight
	Garden cress seed @ 2 %	T <sub>5</sub> 100:0:2 combination of <i>paneer</i> @ 100 %, butter @ 0 % and garden cress seed @ 2 % by weight	T <sub>6</sub> 90:10:2 combination of <i>paneer</i> @ 90 %, butter @ 10 % and garden cress seed @ 2 % by weight	T <sub>7</sub> 80:20:2 combination of <i>paneer</i> @ 80 %, butter @ 20 % and garden cress seed @ 2 % by weight
Garden cress seed @ 3 %		T <sub>9</sub> 100:0:3 combination of <i>paneer</i> @ 100 %, butter @ 0 % and garden cress seed @ 3 % by weight	T <sub>10</sub> 90:10:3 combination of <i>paneer</i> @ 90 %, butter @ 10 % and garden cress seed @ 3 % by weight	T <sub>11</sub> 80:20:3 combination of <i>paneer</i> @ 80 %, butter @ 20 % and garden cress seed @ 3 % by weight

**Table 2 : Moisture changes in Paneer butter spread packed under MAP and stored at 4, 10 and 25 °C**

Temp/days	4 °C	10 °C	25 °C
0 days	49.40±0.46	48.93±0.28	48.78±0.22
5 days	49.19±0.46	48.73±0.34	48.53±0.47
10 days	48.96±0.45	48.59±0.59	46.99±0.11
15 days	48.55±0.37	48.45±0.30	45.07±0.08
20 days	47.54±0.21	47.32±0.41	41.37±0.07
SEM	0.0561	0.0468	0.223
C.D. (P=0.05)	0.183	0.152	0.728

Number of replicate = 3      CD (5%) = Critical difference      SEM = Standard error mean

**Table 3 : Sensory profile of Paneer butter spread packed under MAP and stored at 4, 10 and 25 °C**

Study period	Flavour			Body and texture			Color and appearance			Overall acceptability		
	4 °C	10 °C	25 °C	4 °C	10 °C	25 °C	4 °C	10 °C	25 °C	4 °C	10 °C	25 °C
0	8.58±0.40	8.55±0.53	8.28±0.35	8.45±0.43	8.28±0.47	8.12±0.20	8.32±0.20	8.22±0.20	8.08±0.23	8.47±0.27	8.28±0.40	8.20±0.39
5	8.38±0.35	8.35±0.42	7.78±0.18	7.68±0.37	7.42±0.49	7.38±0.37	7.92±0.55	7.88±0.25	7.45±0.42	8.17±0.31	8.05±0.50	7.52±0.24
10	7.75±0.21	6.05±0.44	5.68±0.24	7.08±0.25	6.28±0.25	5.72±0.43	7.18±0.35	6.58±0.40	5.35±0.33	6.82±0.32	6.02±0.36	5.18±0.35
15	5.12±0.18	4.62±0.30	3.22±0.20	5.48±0.35	4.22±0.30	2.98±0.49	4.18±0.30	3.65±0.35	2.15±0.35	4.22±0.30	3.18±0.26	2.52±0.24
20	3.11±0.12	2.68±0.15	2.42±0.07	2.62±0.37	2.12±0.55	1.55±0.35	1.92±0.26	1.45±0.25	1.35±0.20	2.28±0.20	1.88±0.41	1.18±0.37
S.E.±	0.24	0.24	0.24	0.005	0.21	0.27	0.26	0.24	0.24	0.18	0.26	0.26
C.D.(P=0.05)	0.81	0.81	0.81	0.014	0.70	0.90	0.86	0.81	0.81	0.58	0.86	0.86

acceptability. Table 3 depicts the data for sensory evaluation of *Paneer butter spread* packed under MAP and stored at 4, 10 and 25 °C.

It is evident from Table 3 that the average scores for all sensory attributes decreased significantly with storage period. The maximum score was obtained at day 0 (8.58±0.30) which decreased with progression in the storage period. It can also be seen from the Table 3 that the samples stored at 4 °C scored the maximum among all the samples at all the temperatures. The sensory scores for flavor, body and texture, color and appearance and overall acceptability varying significantly among MAP samples after 20 days of storage at all temperatures.

The changes in sensory characteristics at different temperature in combination with different days are as follows:

#### Flavour:

The average score at 4 °C in different days as 0, 5, 10, 15 and 20 days was 8.58±0.40, 8.38±0.35, 7.75±0.21, 5.12±0.18 and 3.11±0.12, respectively. Similarly at 10 °C the average score was 8.55±0.53, 8.35±0.42, 6.05±0.44, 4.62±0.30 and 2.68±0.15 and at 25 °C the average score was 8.28±0.35, 7.78±0.18, 5.68±0.24, 3.22±0.20 and 2.42±0.07.

#### Body and texture:

The average score at 4 °C in different days as 0, 5, 10, 15 and 20 days was 8.45±0.43, 7.68±0.37, 7.08±0.25, 5.48±0.35 and 2.62±0.37, respectively. Similarly at 10 °C the average score was 8.28±0.47, 7.38±0.49, 6.28±0.25, 4.22±0.30 and 2.12±0.55 and at 25 °C the average score was 8.12±0.20, 7.38±0.37, 5.72±0.43, 2.98±0.49 and 1.55±0.35.

#### Color and appearance:

The average score at 4 °C in different days as 0, 5,

10, 15 and 20 days was 8.32±0.20, 7.92±0.55, 7.18±0.35, 4.18±0.30 and 1.92±0.26, respectively. Similarly at 10 °C the average score was 8.22±0.20, 7.88±0.25, 6.58±0.40, 3.65±0.35 and 1.42±0.25 and at 25 °C the average score was 8.08±0.23, 7.45±0.42, 6.95±0.33, 2.15±0.35 and 1.35±0.20.

#### Overall acceptability:

The average score at 4 °C in different days as 0, 5, 10, 15 and 20 days was 8.47±0.27, 8.17±0.31, 6.82±0.32, 4.22±0.30 and 2.28±0.20 respectively. Similarly at 10 °C the average score was 8.28±0.40, 8.05±0.50, 6.02±0.36, and 3.18±0.26 and 1.88±0.41 and at 25 °C the average score was 8.20±0.39, 7.52±0.24, 5.18±0.35, 2.52±0.24 and 1.18±0.37.

Increase in the temperature had a detrimental effect on the sensory score of the product. The sensory properties viz., colour and appearance, flavour and body and texture was affected the most by an increase in the storage temperature with progression of storage period. None the less, the samples stored at 4°C packed under 60%CO<sub>2</sub>:40%N<sub>2</sub> showed the best preservation of sensory characteristics of the *Paneer butter spread* samples.

#### Microbial analysis of *Paneer butter spread* under MAP :

*Paneer butter spread* samples were analyzed at an interval of 5 days stored at three different temperatures (4, 10 and 25 °C), gas concentration (60% CO<sub>2</sub>:40%N<sub>2</sub>) of the MAP packed samples for microbial changes. Table 4 depicts the TPC, YMC and coliform count obtained for the *Paneer butter spread* samples packed under MAP stored at three different temperatures.

It is evident from Table 4, that the TPC of *Paneer butter spread* samples showed significant variations among samples stored at different temperatures. The

Study period	Total plate count (log CFU/g)			Coliform count (log CFU/g)			Yeast and mold (log CFU/g)		
	4 °C	10 °C	25 °C	4 °C	10 °C	25 °C	4 °C	10 °C	25 °C
0	1.33±0.20	1.46±0.32	1.33±0.20	ND	ND	ND	1.30±0.26	1.33±0.20	1.36±0.23
5	1.36±0.25	1.56±0.15	1.76±0.20	ND	ND	ND	1.33±0.20	1.50±0.30	1.56±0.15
10	1.32±0.30	2.06±0.05	2.90±0.34	ND	ND	ND	1.36±0.25	1.50±0.26	2.70±0.17
15	2.80±0.10	4.36±0.05	4.86±0.05	ND	ND	ND	1.43±0.30	3.63±0.20	4.53±0.15
20	3.86±0.20	4.93±0.20	5.80±0.26	ND	ND	ND	1.63±0.05	4.60±0.10	6.00±0.10
S.E.±	0.02	0.02	0.15	ND	ND	ND	0.04	0.01	0.01
C.D. (P=0.05)	0.07	0.07	0.50	ND	ND	ND	0.13	0.04	0.06

TPC in MAP packed samples increased and varied significantly among samples stored at 4, 10 and 25 °C, the total storage period of 20 days after which it was rendered unacceptable on sensory basis. The no. of TPC in 0 days at 4, 10 and 25 °C was  $1.33 \pm 0.20$ ,  $1.56 \pm 0.32$  and  $1.33 \pm 0.20$ , respectively. Similarly in 5 days  $1.36 \pm 0.25$ ,  $1.56 \pm 0.15$  and  $1.76 \pm 0.20$ , in 10 days  $1.32 \pm 0.30$ ,  $2.06 \pm 0.05$  and  $4.86 \pm 0.05$  and in 20 days  $3.86 \pm 0.20$ ,  $4.93 \pm 0.20$  and  $5.80 \pm 0.26$  TPC was detected.

The number of Coliform was not detected during study period of 20 days. The yeast and mold count in 0 days at 4, 10 and 25 °C was  $1.30 \pm 0.26$ ,  $1.33 \pm 0.20$  and  $1.36 \pm 0.23$ , respectively. Similarly in 5 days  $1.33 \pm 0.20$ ,  $1.40 \pm 0.30$  and  $1.56 \pm 0.15$ , in 10 days  $1.36 \pm 0.25$ ,  $1.50 \pm 0.26$  and  $2.70 \pm 0.17$ , in 15 days  $1.43 \pm 0.30$ ,  $3.63 \pm 0.20$  and  $4.53 \pm 0.15$  and in 20 days  $1.63 \pm 0.10$ ,  $4.60 \pm 0.10$  and  $6.00 \pm 0.10$  YMC was detected.

Among MAP samples, the general trend in the TPC and YMC was  $4\text{ °C} < 10\text{ °C} < 25\text{ °C}$ , during the storage period of 20 days. No coliforms were detected in of the any samples. The microbiological quality of the *Paneer butter spread* samples at the time of packaging as good as it is possible, without working under sterile conditions.

### Changes in HMF content of *paneer* butter spread under MAP :

HMF is the byproduct formed during browning reactions such Maillard reaction. It is known as the indicator of browning and is calculated to determine the degree of browning in the product. *Paneer butter spread* being a heat desiccated product has some degree of characteristic browning. However, high level of browning would be undesirable in this product, as it will render the product unacceptable by the consumer. The HMF content for *Paneer butter spread* samples packed under the air and the MAP conditions stored at 4, 10 and 25 °C are depicted in Fig. 1. (a, b and c). The HMF content for the control samples varied with variation in the temperature. The sample stored at 4 °C, showed minimal change in the HMF content, as compared to the samples stored at 10 and 25 °C. The HMF content of the samples increased gradually with progression in the storage period. It was found to be the lowest ( $5.5 \pm 0.04$ ) in samples packed under 60%N<sub>2</sub>:40%CO<sub>2</sub> stored at 4 °C, while it was the highest ( $8.3 \pm 0.41$ ) in the samples packed under simple stored at 25 °C at day 12.

The HMF content of the control samples reached

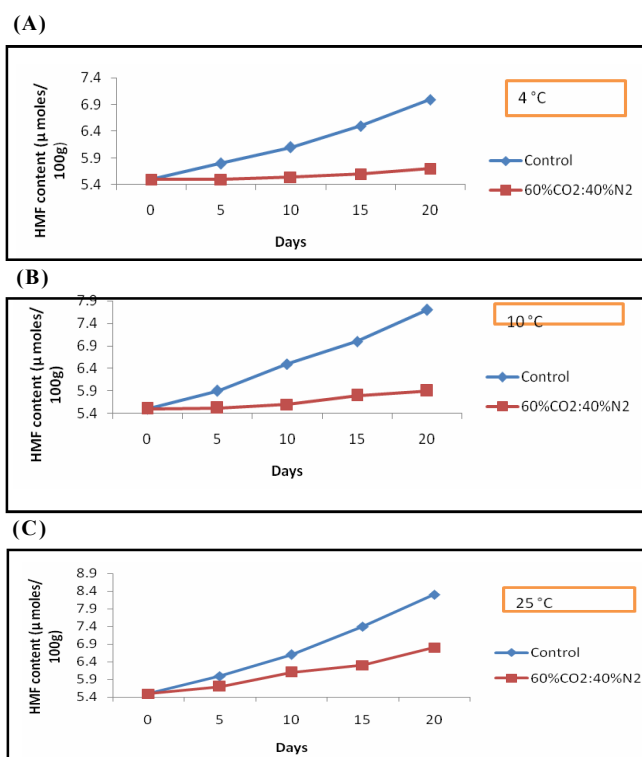


Fig. 1: Hydroxy methyl furfural (HMF) content of *Paneer butter spread* samples stored under air (control) and MAP at different storage temperatures a) 4°C b) 10 °C c) 25°

its highest level ( $8.3 \pm 0.41$ ) at day 20. Thus, it could be stated that the HMF content of the *Paneer butter spread* was highly affected by the alteration in the gas composition under which it is stored and the gas composition of 60% N<sub>2</sub>: 40% CO<sub>2</sub> was found to be the most desirable in reducing the rate of formation of HMF. Londhe *et al.*, (2012) and Jha *et al.*, (2013) reported that combination of CO<sub>2</sub> and N<sub>2</sub> showed better results in the prevention of HMF formation in the brown peda and the *Lal peda*, respectively. Current findings are in accordance with their observations.

### Changes in TBA values :

*Paneer butter spread* contains considerable amount of fat (30.98%), making it highly susceptible to oxidation. TBA value is an indicator of the oxidative changes in a product. Fig. 4.6 (a, b and c) shows the TBA values for *Paneer butter spread* samples stored under air and MAP at 4, 10 and 25 °C.

The TBA values for the *Paneer butter spread* samples increased gradually with the storage period. It can be observed from Fig. 4.6 that the TBA values increased with change in the storage temperature *viz.*,

4°C (Fig. 2a), 10°C (Fig. 2b) and 25 °C (Fig. 2c). It was also found to be affected by the variation in the gas composition in the MAP samples. The general increasing trend of TBA observed in the MAP samples was 60%N<sub>2</sub>:40%CO<sub>2</sub>< control sample. The control samples (packed under air) showed high TBA values during 10 days of storage as compared to the MAP samples. Therefore, it could be concluded that the samples stored at MAP underwent slow deteriorative changes as compared to the samples packed under air. Similar observations were reported by Jha *et al.* (2013). Meshref and Al-Rowaily (2008) reported that increased TBA value for milk and other dairy products subjected to heat treatment. As *Paneer spread* is a heat desiccated dairy product, oxidation may set in during the processing, thus, increases the TBA value. Similar observation was made by Ghayal *et al.* (2013).

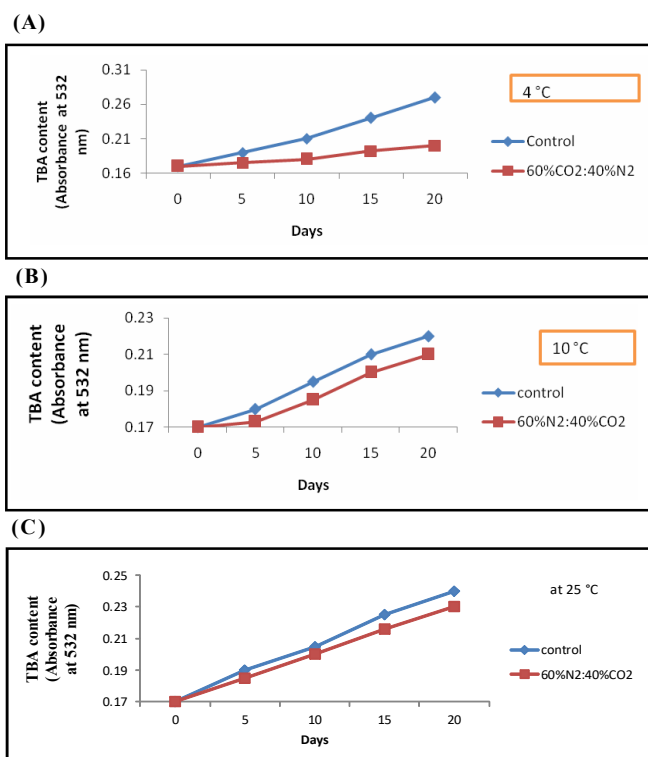


Fig. 2 : Thiobarbituric acid (TBA) value of *Paneer butter spread* samples stored under air (control) and MAP at different storage temperatures a) 4 °C b) 10 °C c) 25 °C

### Changes in the FFA of *Paneer butter spread* under MAP :

FFA is a measure of the liberation of free fatty acids from the fat globules because of processing or degradation of fat content occurring during or after manufacturing. The FFA content of the *Paneer butter*

*spread* samples stored under air and MAP at 4°C, 10 °C and 25 °C is depicted in Fig. 4.7; The FFA content of the *Paneer butter spread* samples showed an increasing trend with progression of the storage period. Several previous workers have reported similar trends in increase in FFA content of *Khoa* during the storage period (Jha *et al.*, 1977 and Kumar *et al.*, 2010).

It is evident from Fig. 3 (a, b and c) that the FFA values were highly affected by the temperature of the storage. The values were found the lowest for the samples stored at 4°C (Fig. 3a) which further increased in case of samples stored at 10°C (Fig. 3b) and 25 °C (Fig. 3c). It can also be seen that FFA content was also affected by the gas composition under which product is stored in MAP. The general increasing trend of FFA content observed in MAP samples was 60% N<sub>2</sub>:40% CO<sub>2</sub>< control sample. The control samples (packed under air) showed high FFA values during 10 days of storage as compared to the MAP samples. Oxygen is the chief causative agent of oxidation in lipids causing high FFA value. Thus, the delayed lipolysis of *Paneer butter spread* samples stored under MAP could be attributed to the absence of oxygen in the package. Similar findings were reported by Londhe *et al.* (2012),

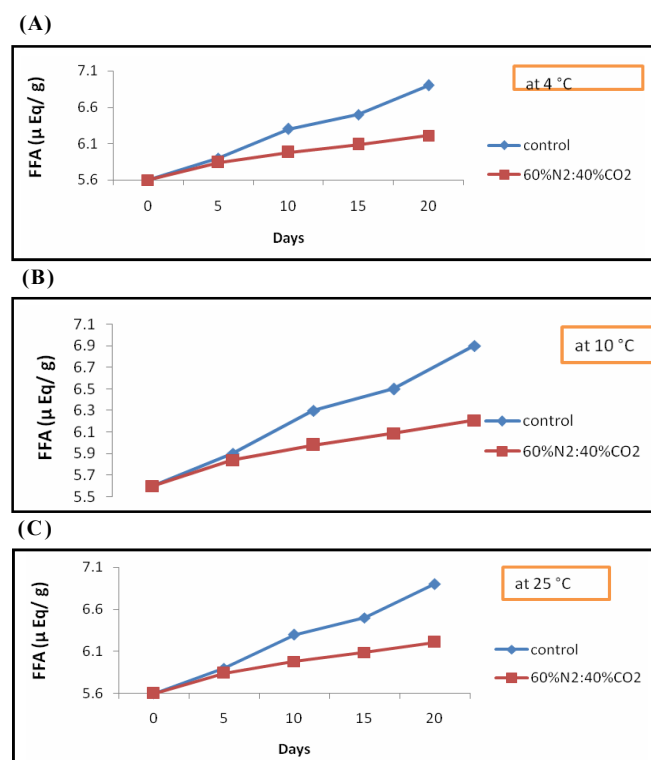


Fig. 3 : Free fatty acid (FFA) value of *Paneer butter spread* Samples stored under air (control) and MAP at different storage temperatures a) 4°C b) 10°C c) 25°C

Jha *et al.* (2013) and Ghayal *et al.* (2013).

However, it was observed that the samples stored at 60% CO<sub>2</sub>:40% N<sub>2</sub>, inhibited the microbial growth with great efficiency. This could be attributed to the combined benefits of N<sub>2</sub> and CO<sub>2</sub> as reported by several earlier workers (Daniels *et al.*, 1985; Banks and Annis 1990; Davis 1998; Devlieghere and Debevere, 2000, Arvanitoyannis *et al.*, 2011; Ghayal *et al.*, 2013 and Jha *et al.*, 2013).

Smith *et al.*, (1986) reported that crutty rolls packed in MAP (40% N<sub>2</sub>:60% CO<sub>2</sub>) remained mold free even for as much as 20 days, Thus the findings related to the microbial analysis do not collaborates with the findings of aforementioned experiments. This might be due to the difference between the *Paneer butter spread* and the dairy products taken by earlier mentioned workers.

### Conclusion:

The samples packed under 60% CO<sub>2</sub>:40% N<sub>2</sub> were more successful in preserving the moisture, sensory and microbial properties of *Paneer butter spread* at 4 °C as compared to samples stored at 10 °C and 25 °C. Further, the samples stored at MAP underwent slow deteriorative changes as compared to the samples packed under air. Therefore, it may be concluded that, the product stored under MAP had the best shelf-life of 10 days at 4°C based on its sensory and physic-chemical evaluation and microbial counts.

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