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Standardisation and quality evaluation of bottle gourd based RTC product enriched with milk paneer

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Abstract

The study aimed to develop and standardise a ready to cook (RTC) bottle gourd based breaded ball enriched with milk paneer and to assess its physicochemical qualities during frozen storage. Bottle gourd was partially replaced with milk paneer at levels of 10 to 50%, and the formulation containing 30% paneer was found most acceptable based on sensory evaluation. The enriched RTC product showed higher protein (6.59%), fat (12.20%), calcium (114.25 mg/100 g), and phosphorus (72.40 mg/100 g) contents compared to the control. Minimal variations were observed in pH, moisture, and water activity and no microbial growth occurred during three months of frozen storage, confirming excellent product stability. Incorporation of milk paneer enhanced the nutritional value, texture, and sensory appeal of the RTC product, demonstrating its potential as a nutritious, protein enriched, and shelf stable convenience food for modern consumers.

Keywords: Bottle gourd, milk paneer, ready-to-cook product, frozen storage, nutritional enrichment, sensory quality, microbial safety

Introduction

Bottle gourd (*Lagenaria siceraria* (Molina) Standl.) popularly known as *lauki* is a low-calorie cucurbit vegetable, valued for its rich composition of vital nutrients beneficial to human health and wellbeing (Gupta *et al.*, 2022) [6]. It is a climber, which produces smooth, light green, bottle shaped fruits, known for its therapeutic applications in managing conditions such as cardiovascular diseases, liver disorders and gastric ulcers. Due to its high potassium content, bottle gourd juice is said to be effective in regulating blood pressure among hypertensive individuals. Additionally, its high dietary fibre and low-fat content make it an excellent choice for weight management, and it is traditionally recognised as a natural guard against various ailments (Bhutani, *et al.*, 2025) [3]. Because of its mild flavour and soft texture, bottle gourd is amenable to processing into various value-added products, including soups, purees, cakes and vegetable blends (Barot *et al.*, 2015) [4].

In recent years, the market for ready to cook (RTC) or ready to eat (RTE) vegetable-based convenience products have expanded rapidly, driven by consumer demand for nutritious, time saving foods. However, developing RTC products from vegetables like bottle gourd poses challenges such as low intrinsic protein, poor water holding during cooking or reheating, and microbial instability during storage. To overcome the protein deficiency and enhance textural and nutritional quality, protein enrichment using dairy ingredients is a viable strategy.

Paneer, a traditional acid coagulated dairy product, is a rich and affordable source of protein, especially popular in vegetarian diets. Paneer are known for their high digestibility and superior biological value in the range of 80 to 86, making it an excellent source of high-quality protein in the human diet (Khan and pal, 2011) [11]. Paneer can also contribute moisture binding capacity and fat protein network structure, while incorporating into vegetable matrices, can improve the firmness, mouthfeel, and protein profile of the product.

Therefore, this work was formulated to standardise RTC bottle gourd based breaded balls enriched with milk paneer, and to evaluate its physicochemical and microbiological stability during frozen storage. By combining the nutritional benefits of bottle gourd with high quality protein, this work was aimed to develop a value added, nutritionally rich, and shelf stable RTC convenience food suitable for wider consumer acceptance.

Materials and Methods

Collection of raw materials

Fresh bottle gourds required for the preparation of breaded products were procured from the local vegetable market in Thrissur, Kerala. All other ingredients required for the product development were also purchased from the local market.

Preparation of milk paneer

Milk paneer was prepared following the method of Kumar *et al.* (2014) [12]. Homogenised toned milk was heated to 85-90°C for 15 minutes, and 0.15% calcium chloride was added. After cooling to 70°C, coagulation was induced using 2% citric acid with continuous stirring until curd and clear whey separated. The curd was allowed to settle for 10 minutes, then filtered through cheesecloth and pressed by putting weight for 15-20 minutes to remove excess moisture. The paneer was then packed in polythene covers and stored under refrigeration (4 ± 1°C). The yield was approximately 120 g paneer per litre of milk.

Standardisation of milk paneer incorporated breaded balls

Milk paneer incorporated RTC breaded balls were prepared by partially replacing shredded bottle gourd with milk paneer at different levels. The product was formulated based on the conventional method (Bhargava, 2004) [2] used for vegetable breaded ball preparation with suitable modifications. Milk paneer incorporated breaded balls were standardised by replacing bottle gourd at varying levels ranging from 10 to 50% with milk paneer, as shown in Table 1. Other ingredients were used in same level in all treatments *viz*. salt (1.5%), dried spice mix (2.5%), condiments (10%) and flour mix (10%). The control treatment consisted of 100% bottle gourd. After cooking, the cooked mass was made into balls of 20g size, coated with batter and later with bread crumbs.

Table 1: Treatments for the standardisation of bottle gourd based RTC breaded balls enriched with milk paneer

Treatments	Bottle Gourd (%)	Milk Paneer (%)
T_0 (Control)	100	0
T_1	90	10
T_2	80	20
T_3	70	30
T_4	60	40
T_5	50	50

Organoleptic evaluation

Sensory evaluation of the prepared milk paneer enriched RTC breaded balls was carried out using score card of nine-point hedonic scale by a panel of 20 judges for sensory parameters, appearance, colour, flavour, texture, taste and overall acceptability. The samples were deep fried in vegetable oil and served for evaluation. Among the different treatments (T_0–T_5), the most acceptable formulation was selected based on the mean sensory scores. The selected best treatment was used for further storage and quality evaluation studies along with the control.

Quality evaluation of RTC products during storage

The selected RTC milk paneer incorporated bottle gourd based breaded balls were packed in polyethylene covers (100 microns) and stored under frozen (–18°C or below) conditions for three months. Physico-chemical qualities were evaluated initially and at monthly intervals using standard methods. All analyses were performed in triplicate.

Physio- chemical qualities of RTC products on storage

Water activity

The water activity (aw) was measured using a calibrated digital water activity meter. Prior to testing, the instrument was calibrated using salt solutions of known aw values to ensure accuracy. Around 5–10 g of the sample was placed in a clean sample cup and positioned within the sealed chamber of the device. The aw reading was recorded once it is stabilised (Fontana, 2007) [5].

pH

The pH was measured using a digital pH meter fitted with a calibrated glass electrode. The device was first calibrated with standard buffer solutions at pH 4.0 and 7.0 to ensure accurate readings. A homogenised portion of the sample was placed in a clean beaker, and the electrode was inserted into the centre of the sample. The pH reading was noted once it stabilised.

Moisture

Moisture content of the RTC products was estimated following the A.O.A.C (2023) method. Approximately 5 g of the sample was placed in a clean petridish and dried in a hot air oven maintained at 60 to 70°C. After drying, the sample was cooled in a desiccator and weighed. This process of drying, cooling and weighing was repeated until a constant weight was obtained. Moisture content was calculated based on the weight loss during drying and expressed as a percentage

Protein

Protein content was estimated using the A.O.A.C (2023) method. 0.2 g sample was digested with sulfuric acid along with copper and potassium sulfate as catalysts. After digestion, the mixture was diluted, made alkaline with sodium hydroxide, and distilled. The released ammonia was collected in boric acid and titrated with hydrochloric acid to determine nitrogen content, which was then multiplied by 6.25 to calculate the protein percentage.

Total Carbohydrate

The carbohydrate content was measured colourimetrically using anthrone reagent (Sadasivam and Manickam, 2022) [16]. 0.2 g was hydrolysed with 5 mL of 2.5 N HCl, cooled and the residue was neutralised with solid sodium carbonate. Made up the content to 100 mL in a standard flask and centrifuged. Pipetted 0.1 mL of supernatant, added1 mL of distilled water and 4 mL anthrone reagent. Heated the contents for eight minutes cooled and the intensity of colour from green to dark green was read at 630 nm. a standard graph was prepared using standard glucose at serial dilutions. From the standard graph, the amount of total carbohydrate present in the sample was estimated and expressed in percentage.

Fat

Fat content was determined using a modified solvent extraction method (Sadasivam and Manickam, 2022) [16]. One gram of the sample was mixed with hexane, and the fat was extracted into the solvent. After separation, the hexane layer was collected and evaporated on a water bath. The remaining fat residue was weighed, and the fat content was calculated as a percentage of the sample. All measurements were done in triplicate.

Fibre

Fibre content was estimated using the method of (Sadasivam and Manickam, 2022) [16]. About 2 g of the sample was sequentially boiled with 1.25% sulfuric acid and 1.25% sodium hydroxide, followed by thorough washing. The residue was dried, weighed, ignited in a muffle furnace at 600°C, and reweighed. Crude fibre was calculated based on the weight loss after ignition and expressed as a percentage of the sample.

Ash

Ash content was determined following the ISI (1980) [8] method. About 5 grams of the sample was placed in a crucible and incinerated in a muffle furnace at 500–600°C for 5 to 6 hours. After cooling in a desiccator, the residue was weighed, and ash content was calculated as a percentage of the original sample weight.

Calcium

Calcium content of RTC products was determined by Atomic Absorption Spectrophotometry (Perkin-Elmer, 1982) [14] using diacid extract prepared from 1 g sample digested with 10 ml nitric acid - perchloric acid (9:4), made up to 100 ml, and expressed as mg/100 g.

Phosphorus

Phosphorus content was determined colorimetrically (Jackson, 1973) [9] by mixing 5 mL of predigested sample with 5 mL phosphorus reagent, diluting to 50 mL and measuring absorbance at 420 nm. Values were calculated from a standard curve and expressed as mg/100 g sample.

Sodium

The sodium content in the product was estimated using the method described by Jackson (1973) [9]. One gram of the finely ground dried sample was digested using a diacid mixture and the resulting digest was diluted to a final volume of 100 mL with distilled water. A 1 mL aliquot of this solution was introduced into a flame photometer and the sodium concentration was determined by comparing the reading with that of standard sodium solutions.

Potassium

Potassium content of the samples was analysed by Atomic Absorption Spectrophotometer (Perkin-Elmer, 1982) [14]. About 1 g of the sample was digested with 10 mL of nitric–perchloric acid mixture (9:4) and the volume was made up to 100 mL with distilled water. The digested extract was directly aspirated into the instrument, and the concentration of potassium was calculated from a standard curve. The results were expressed as mg/100 g of sample.

Peroxide value

Peroxide value was determined by the iodometric titration method (AOAC, 2023) [1]. Five grams of sample was mixed with 30 mL of glacial acetic acid–chloroform (3:2) and 0.5 mL of saturated KI solution, kept in the dark for 1 min. After adding 30 mL distilled water, the liberated iodine was titrated with 0.01 N sodium thiosulfate using 1 mL starch as indicator, until the blue color disapeared. A blank was run under identical conditions, and results were expressed as meq O_2/kg sample.

Statistical Analysis

The data on quality evaluation of RTC bottle gourd-based products was analysed statistically using a Completely Randomized Design (CRD). Organoleptic evaluation results were subjected to Kendall's Coefficient (W). The difference in physico-chemical parameters between treatments were analysed using 't' test and changes over storage was assessed by using Duncan's Multiple Range Test (DMRT).

Result and Discussion

Organoleptic qualities of bottle gourd based RTC products enriched with milk paneer

The sensory scores for milk paneer incorporated breaded balls revealed that treatment T_3 with 70% bottle gourd and 30% milk paneer received the highest scores for all attributes (Table 2).

The mean scores for different organoleptic qualities of T_3 was appearance (8.52), colour (8.88), flavour (8.33), texture (8.19), taste (8.04) and overall acceptability (8.05).

The total sensory score for T_3 was 50.01 and was found to be higher than the total score of control (45.86) and other treatments. Thus, T_3 was selected for storage studies. The incorporation of paneer significantly improved the flavour and taste of the RTC products. Similar findings have been reported in vegetable dairy functional foods, where partial incorporation of dairy or protein rich ingredients improved flavour, body, and texture (Velpula *et al*., 2018) [18]. In their study, bottle gourd halwa prepared with 20% skim milk powder was found to be most acceptable, with overall sensory quality comparable to the control. Jandyal *et al*. (2018) [10] standardised fibre enriched egg koftas with 30 % bottle gourd and reported that bottle gourd incorporation improved the overall acceptability of the product.

Physico chemical qualities of RTC products during storage

Water activity

The water activity of the frozen RTC breaded balls showed minimal variation throughout the storage period. Initially, the milk paneer incorporated treatment (T_1) exhibited water activity of 0.90 and in control it was 0.87. In both products it reduced to 0.89 and 0.86 in one month and later remain unchanged. Jandyal *et al*. (2018) [10] reported water activity of 0.84 to 0.95 in fibre enriched egg *koftas* prepared with 10 to 30 percent bottle gourd in which they reported increasing water activity with increase in the proportion of bottle gourd. In this study, bottle gourd was used after removing a major portion of water content from bottle gourd. That may have help to reduce the wate activity of control product.

pH

During frozen storage, the pH of both the control (T_0) and milk paneer incorporated bottle gourd-based RTC breaded balls showed a gradual decline over time. The control initially exhibited a higher pH of 6.80, decreasing to 6.54 after three months, while the milk paneer-incorporated product recorded a lower initial pH, reaching 5.68 at the end of storage. This gradual reduction in pH indicates mild acidification during storage, which remained within acceptable limits, confirming good product stability under frozen conditions. Similar trends have been reported in pumpkin-incorporated chicken sausages, where Zargar *et al*. (2014) [22] observed a gradual decrease in pH over refrigerated storage, attributed to biochemical changes in the food matrix. These observations suggest that incorporation of protein or vegetable-based ingredients, such as milk paneer can influence pH dynamics during storage.

Moisture

During frozen storage, both the control and milk paneer-incorporated bottle gourd-based RTC breaded balls exhibited a slight decrease in moisture content over time. The control initially contained 56.50%, which decreased to 53.20% after three months, while enriched product showed an initial value of 57.20%, declining marginally to 55.30% by the end of storage. The gradual reduction in moisture may be attributed to sublimation of free water, resulting in slow dehydration of the product. Similar observations were reported by Qureshi *et al.* (2019) [15] in paneer supplemented with different date (*Phoenix dactylifera* L.) extracts, where a progressive yet limited decline in moisture was recorded during frozen storage, attributed to water redistribution and surface evaporation. Hence, the slightly higher moisture retention observed in the milk paneer incorporated formulation may be due to the combined effect of its protein fat network and the water binding ability of paneer, which helped maintain desirable texture even after extended frozen storage.

Protein

During frozen storage, the protein content of both the control and milk paneer incorporated bottle gourd based RTC breaded balls exhibited a gradual decline over time. The control initially contained 1.70% protein, which decreased to 1.52% after three months. In comparison, the milk paneer incorporated product had a higher initial protein content of 6.59%, declining to 6.39% by the end of storage. This minimal decrease in protein content indicates good protein stability during frozen storage. The consistently higher protein levels in enriched product throughout the storage period reflect the effective enrichment achieved through milk paneer incorporation. Supporting these findings, Hamouda and Salunke (2024) [7] observed that the protein content in skim milk remained stable during low temperature storage, with only a slight decrease over time. Their study suggests that milk proteins can maintain functionality and stability under similar storage conditions, aligning with the results observed in the current study.

Total Carbohydrate

During frozen storage, the total carbohydrate content of the control product decreased from 7.86% initially to 6.68% after three months, whereas the milk paneer incorporated product showed a slightly higher initial carbohydrate content of 7.83%, reducing marginally to 6.74% over the same period. This indicates that both formulations effectively retained carbohydrates under frozen conditions, with T_1 showing a slight advantage due to paneer incorporation. Similar findings were reported by Solanki and Arunkumar (2024) [17], who observed carbohydrate levels in functional extruded paneer products ranging between 7.5-8%, highlighting the stabilizing effect of protein incorporation on carbohydrate retention.

Fat

The fat content of control was initially 5.40%, whereas enriched product contained 12.20%, reflecting the fat contribution in the product by milk paneer. During storage, a minor reduction was observed, with values decreasing to 5.08% in and 11.99% respectively. Verma and Chawla (2020) [19] also reported that paneer enriched convenience foods retained higher fat levels during storage, supporting the stabilising role of dairy fat in processed products.

Fibre

The initial fibre content of the control was 2.04%, which decreased slightly to 2.02% after three months of frozen storage. In milk paneer incorporated breaded balls, the initial fibre content was lower at 1.38% and marginally reduced to 1.33% by the end of the storage period. The reduction was statistically insignificant, indicating good fibre stability under frozen conditions. This aligns with the findings of Jandyal *et al.* (2018) [10], who reported stable fibre levels in bottle gourd–enriched kofta products during storage, confirming good fibre retention in vegetable- and protein-enriched foods.

Total Ash

The total ash content was initially 0.60% in the control and 0.97% in enriched product reflecting the mineral enhancement achieved with milk paneer incorporation. After three months of frozen storage, ash content decreased to 0.29% and 0.45%. Despite the reduction, enriched product maintained significantly higher ash levels throughout storage, demonstrating better mineral retention. . Yadav *et al.* (2019) [21] reported similar trends in herbal paneer, noting that fortified paneer retained higher ash content during storage, supporting the better mineral retention observed in enriched product.

Calcium

Calcium content was markedly higher in enriched product (114.25 mg/100g) compared to control (35.04 mg/100g) initially. During frozen storage, a slight reduction was observed, with final values of 31.32 mg/100g in the control and 111.88 mg/100g in T_1 after three months. Li *et al.* (2017) [13] reported calcium retention in frozen dairy products and vegetable blends in the range of 110–115 mg/100g, corroborating the effective preservation of calcium in products. The minimal loss under frozen conditions indicates effective preservation of calcium in milk paneer based RTC products.

Phosphorus

Phosphorus content in the control product was 27.13 mg/100g initially, reducing slightly to 24.10 mg/100g after frozen storage. The milk paneer incorporated product had a significantly higher phosphorus level of 72.40 mg/100g initially, which reduced marginally to 65.36 mg/100g at the end of three months. Weaver and Givens (2025) [20] emphasised the role of protein-rich matrices, such as paneer, in maintaining phosphorus levels during storage, consistent with the higher retention in enriched product

Sodium

Initially, the sodium content in control was 2.60 mg/100g, while enriched product recorded a much higher value of 8.30 mg/100g due to the mineral content of paneer. After three months of frozen storage, the sodium content decreased slightly to 1.99 mg/100g and 7.69 mg/100g in both products. The decline was minor, confirming the mineral stability of frozen products. Khan and Pal (2011) [11] highlighted that milk paneer contributes significantly to sodium content in fortified foods, and minor losses during storage did not compromise nutritional quality.

Potassium

The potassium content in control was 180.20 mg/100g initially, decreasing to 155.13 mg/100g after three months. In enriched product potassium was 159.60 mg/100g initially and reduced slightly to 151.88 mg/100g at the end of storage. Although a minor decline was observed, the retention of potassium was satisfactory in both treatments. Solanki and Arunkumar (2024) [17] also reported potassium levels in paneer-enriched products ranging from 150–160 mg/100g.

Peroxide Value

The peroxide value of both the products was below the detectable levels throughout the storage indicating no lipid oxidation and confirming the excellent oxidative stability of the products under frozen conditions.

Overall, the data indicate that milk paneer incorporation significantly enhanced the protein, fat and mineral content of RTC bottle gourd-based breaded balls while ensuring minimal losses of carbohydrates, fibre and minerals during frozen storage, highlighting its functional and nutritional value.

Conclusion

The study demonstrated that incorporating 30% milk paneer into bottle gourd based RTC breaded balls significantly improved their protein, fat, and mineral content while maintaining good sensory quality and microbial stability during frozen storage. The product remained nutritionally rich, safe, and highly acceptable up to three months, highlighting its potential as a convenient, protein-enriched functional food for modern consumers.

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Table 2: Mean scores for organoleptic qualities of bottle gourd based RTC products enriched with milk paneer

Parameters	Treatments						W
	T_0	T_1	T_2	T_3	T_4	T_5	
Appearance	8.30 (3.15)	8.16 (2.75)	8.28 (3.10)	8.52 (5.23)	8.33 (2.99)	8.35 (3.80)	0.323**
Colour	8.00 (1.83)	8.07 (2.28)	8.16 (2.48)	8.88 (5.90)	8.50 (4.48)	8.38 (4.05)	0.827**
Flavour	7.50 (3.70)	7.35 (2.50)	7.40 (2.68)	8.33 (5.90)	7.43 (2.68)	7.52 (3.55)	0.570**
Texture	7.47 (3.35)	7.5 (2.43)	7.45 (2.65)	8.19 (5.45)	7.54 (2.63)	7.85 (4.50)	0.484**
Taste	7.23 (2.68)	7.16 (2.58)	7.26 (2.90)	8.04 (5.50)	7.28 (2.33)	7.76 (5.03)	0.602**
Overall acceptability	7.36 (3.75)	7.14 (2.23)	7.11 (1.98)	8.05 (5.90)	7.33 (3.33)	7.41 (3.83)	0.652**
Total score	45.86	45.82	45.66	50.01	46.41	47.27	

W- Kendall's coefficient of concordance Figures in parenthesis indicate mean rank scores

** significant at 1% level

T_0 – 100 % BG (control) T_1 – BG 90 % + MP 10 % T_2 – BG 80 % + MP 20 T_3 – BG 70 % + MP 30 %

T_4 – BG 60 % + MP 40 % T_5 – BG 50 % + MP 50 % (BG – Bottle gourd, MP – Milk paneer)

Table 3: Effect of frozen storage on physico-chemical properties of bottle gourd based RTC product enriched with milk paneer

Treatments	Storage interval				
	Initial	1st month	2nd month	3rd month	CD (0.05)
Water activity					
T_0	0.87	0.86	0.86	0.86	NS
T_1	0.90	0.89	0.89	0.89	NS
T- Value	NS	NS	NS	NS	
pH					
T_0	6.80^{a}	6.70^{b}	6.65^{c}	6.54^{d}	1.00
T_1	5.90^{a}	5.80^{b}	5.69^{c}	5.68^{d}	1.02
T- Value	0.06**	0.066**	.023**	.051**	
Moisture					
T_0	56.50^{a}	53.20^{b}	53.20^{c}	53.20^{d}	0.303
T_1	57.20^{a}	55.30^{b}	55.30^{c}	55.30^{d}	0.224
T- Value	.185*	.147*	.158*	.175*	
Protein					
T_0	1.70^{a}	1.68^{b}	1.60^{c}	1.52^{d}	0.290
T_1	6.59^{a}	6.52^{b}	6.44^{c}	6.39^{d}	0.194
T- Value	.516*	.523**	.508**	.514**	
Total carbohydrate					
T_0	7.86^{a}	7.64^{b}	7.12^{c}	6.68^{d}	0.212
T_1	7.83^{a}	7.71^{b}	7.15^{c}	6.74^{d}	0.136
T- Value	NS	NS	NS	NS	
Fat					
T_0	5.4^{a}	5.39^{b}	5.25^{c}	5.08^{d}	0.189
T_1	12.2^{a}	12.15^{b}	12.09^{c}	11.99^{d}	0.083
T- Value	.022**	.012**	.025**	.045**	
Fibre					
T_0	2.04	2.03	2.03	2.02	NS
T_1	1.38	1.34	1.33	1.33	NS
T- Value	.004**	.004**	0.11**	.004**	
Total ash					
T_0	0.60^{a}	0.50^{b}	0.39^{c}	0.29^{d}	3.871
T_1	0.97^{a}	0.84^{a}	0.69^{a}	0.45^{b}	1.356
T- Value	.034**	.032**	.040**	.099**	
Calcium					
T_0	35.04^{a}	34.32^{b}	32.32^{c}	31.32^{d}	0.030
T_1	114.25^{a}	113.95^{b}	112.87^{c}	111.88^{b}	0.010
T- Value	.024**	.045**	.055**	.042**	
Phosphorus					
T_0	27.13^{a}	26.11^{b}	25.11^{c}	24.10^{d}	0.039
T_1	72.40^{a}	70.37^{b}	67.36^{c}	65.36^{d}	1.552
T- Value	.345*	.312*	.422*	.415*	
Sodium					
T_0	2.60^{a}	2.42^{b}	2.08^{c}	1.99^{d}	0.402
T_1	8.30^{a}	8.08^{b}	7.87^{c}	7.69^{d}	0.125
T- Value	.003**	.001**	.001**	.001**	
Potassium					
T_0	180.2^{a}	177.14^{b}	167.14^{c}	155.13^{d}	0.006
T_1	159.6^{a}	157.89^{b}	154.89^{c}	151.88^{d}	0.006
T- Value	.304*	.154*	.453*	.778*	

T_0 – 100 % BG (control) T_1 – BG 70 % + MP 30 % (BG – Bottle gourd, MP – Milk paneer)

NS- Non-significant

Different superscripts within a row (a, b, c, d) indicate significant differences between storage intervals as determined by critical difference (CD) at 5% level

Colum wise indicate significant differences between treatments as determined by t-Value * significant at 5% and ** significant at 1%

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