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# Texturized egg albumen as an alternative to traditional *paneer*: Evaluation of quality and shelf stability

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**Abstract:** A shelf stable, low fat (< 1%) *paneer* like product was made from egg albumen. This texturized egg albumen product, labeled as egg albumen *paneer* (EAP), was developed by texturizing liquid egg albumen by incorporating optimized quantities of wheat flour and rice flour. Dehydrated EAP was packed in metalised polyester pouches, stored at ambient temperature (27±2°C) for 6 months and sampled periodically for quality evaluation. The protein content of dehydrated EAP was 21.08±1.35%. The shelf stability of the product was achieved by keeping a moisture content (9.68±1.02%) and water activity (0.54±0.02) low. A significant increase ($p \leq 0.05$) in the volume of EAP was observed on rehydration. The rehydration capacity was 84.10±5.35% for the product. During first three months of storage, there was a marked change ($p \leq 0.05$) in rehydration ratio; however, further storage did not affect it. Storage period did not significantly ($p \geq 0.05$) affect the lipid oxidation parameters, physical properties, textural profile and colour traits of the product. The standard plate counts and yeast and mould counts fluctuated within the range of 0.90±0.05 - 3.25±0.05 and 0.84±0.04 - 2.52±0.33 log cfu/g, respectively during storage. *Staphylococcus aureus*, *E. coli*, *Salmonella* and *Shigella*, however, were not detected in any sample throughout the storage period. Sensory evaluation revealed that rehydrated *paneer*, the product had excellent texture, and was very close to fresh ones (before drying) during storage for six months. An average sensory score were 7.5 to 8.7 on 9 point hedonic scale indicated the product was liked very much.

**Keywords: Egg albumen, *paneer*, shelf stable products, rehydration**

## Introduction

Eggs are highly nutritious and have been used to prepare many ways, with various spices and sauces to enhance for natural appealing taste, aroma and appearance. Also the egg is a fairly low-energy source of perfectly balanced proteins and easily digestible lipids and is one of the cheapest sources of protein available to the consumer. Apart from functional outcome, flavour or textural attributes, egg can be a unique and cost effective addition to almost any meal. Eggs are generally consumed in limited forms such as boiled eggs, egg-in-curry, omlette and egg *pakoda* (boiled egg coated with Bengal gram flour and deep fat fried) in India. All these products are freshly prepared and served. With increasing egg production and subsequent impact on the market, the industry has realized the importance of creating demand for processed egg products.

Limited information is available on different egg products, such as egg coated potato (Muller, 1994), premixed flavoured egg product (Wu *et al*., 1995), egg flakes containing monosodium glutamate and onion/garlic extracts (Lee *et al*., 1998), egg white chips containing stabilizers and flavouring (Yang *et al*., 2000), formulated fried egg (Merkle *et al*., 2007), egg loaf containing spices and refined wheat flour (Yashoda *et al*., 2004). A US patent for method of making egg and cheese product was filed by Heick (1997). Research work by the South African Egg Board on new egg products, viz., egg and bacon patty, bite-sized egg snacks, frozen egg pizza, and egg fingers (crumb-coated scrambled eggs and bacon bound by white sauce) has been reviewed by (Willense, 1991). The product egg albumen *paneer* (EAP) is a novel product and first of its kind. (*Paneer* is an acid and heat coagulated milk product used extensively in India for various culinary preparations). No information is available on such a product or any distantly related product in the literature.

Consumer today wants simple to prepare, convenient, healthy and natural foods, and egg contains to provide a viable option for these characteristics. Increased health consciousness among consumers about the risks involved with consumption of fat rich has resulted in an increased demand for healthy foods with low fat. Low fat egg products are one such product that are in demand. The liquid nature of egg albumen does not allow for setting to the extent as *paneer* does. Hence, it was decided to use ingredients that would afford setting and texture improvement of egg albumen upon heating to form a *paneer* like

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product. Since egg albumen has 1.0% fat (Anon, 2011) and keeping in view the consumer's desire, the egg albumen was used for the development of shelf stable EAP. It can be used in curry preparation similar to paneer-in-curry, a delicacy in Indian cuisine. Generally, the traditional milk based *paneer* does not have shelf stability of more than 24 hours at room temperature. Any product that is *paneer* or *paneer* alternative that provides shelf stability would be a welcome by the Indian households. Hence the objective of this work was to produce a dried product that is shelf-stable, has minimum fat, shorter reconstitution time and microbiologically safe, with minimal degradation of nutrients and sensory properties. This work reports on preparation of shelf stable, low fat EAP, and evaluation of its physico-chemical properties, textural quality, microbiological, sensorily acceptability and oxidation changes during storage at ambient temperature (27 ± 2°C).

## Material and Methods

Several trial formulations for development of EAP were attempted using different binders and fillers and time- temperature schedules of processing in order to obtain the product, which was acceptable to taste panelists and did not disintegrate during cooking along with curry, retain the shape and dehydrate easily.

### *Product preparation*

Hen eggs were procured from local market. A batch of 100 eggs (50-55 g each), kept under room temperature (27 ± 2°C), and was broken over a sieve to separate albumen and yolk to obtain batter. The liquid egg albumen (77.3%) was mixed with a wire balloon whisk in Hobart mixer (Model M-50, USA) for 4-5 minutes at speed 2 to get the maximum fully blown foam. Malic acid (0.4%) and citric acid (0.4%) was added at the beginning of beating, when the egg white was just beginning to become frothy. Garlic powder (0.4%) and salt (1.5%), was added at the end of foam formation and mixing was continued for another 1 min. The binder mix containing wheat flour (15.0%) and rice flour (5.0%) was added slowly to homogenize liquid egg while mixing continuously to obtain a batter with homogenous consistency. The mixing was carried out for 3-4 minutes till a uniform smooth batter was obtained. The resultant batter was transferred to rectangular stainless steel moulds of 22 x 9 x 9 cm (l x b x h) dimension lined with polypropylene sheet and the product steamed in at atmospheric pressure for 35 min (internal temperature 86 ± 2°C) to obtain solidified product. The moulds were open steamed (100°C) in a pressure vessel but at atmospheric pressure. Upon completion of steaming, the moulds were cooled at ambient temperature (27 ± 2°C) for 30-45 min. The resultant loaf was cut into cubes by using a cutting mould of 1 x 1 x 1 cm. size. The product was then dried in cross flow dryer (C. M. Equipments and Instruments India Pvt. Ltd, Bangalore, India) by spreading in stainless steel trays at the rate of 0.75 kg per sq.mt. The drying was carried out at 82 ± 3$^o$C for 3 hrs to obtain dried cubes called EAP. The dried EAP were allowed to cool. After cooling, the product was then packed in metalized polyester (polyester 10-11 micron/ aluminum foil 9-12 micron/ polythene 100 gauges) bags of 50 g capacity each and stored at ambient temperature (27 ± 2°C). The stored products were drawn periodically for six months for quality evaluation.

### *Quality evaluation*

*Measurement of physico- chemical quality*

The percentage yield on drying of the product was determined by weighing the EAP before and after drying (Equation -1).

$$\text{Yield (\%)} = \frac{\textit{Wt. of EAP before drying} - \textit{Weight of EAP after drying}}{\textit{Weight of EAP before drying}} \; X\,100 \qquad (1)$$

The percent increase in the volume after rehydration was determined by measuring the volume (length x breadth x height) of cube shaped EAP pieces before and after rehydration by using the equation (2). Samples of regular or healthy edges with uniform dimensions only were selected for the determination of aforesaid test. An average of six measurements was recorded:

$$\textit{Increase in volume (\%)} = \frac{\textit{volume after rehydration} - \textit{volume before rehydration}}{\textit{volume before rehydration}} \; X\,100 \qquad (2)$$

Rehydration was carried out following the procedure described by (Ranganna, 1995) with some modifications. Fifteen gram sample was placed in 500 ml beaker, 300 ml of distilled water was added, and covered with watch glass, brought to a boil within two minutes on an electric heater, and boiled for 3 minutes. The ratio of sample to water was fixed (1:20; w/v) taking into consideration end use of product in traditional curry preparation. Temperature of the heater was controlled to avoid excess boiling and evaporation of water. The samples were removed from the heater and transferred into a 100 mm glass funnel, drained for two minutes undisturbed, until the drip from the funnel has to be read as stopped, removed from the funnel and weighed. Set the drained rehydrated EAP samples aside in covered petri-plates for textural profile and shear force analysis.

Coefficient of rehydration, rehydration ratio, and percent rehydration in terms of percent water in rehydrated EAP (Eqn.3, 4 and 5), were calculated as described by (Ranganna, 1995). Bulk density of the product was determined as weight of a unit volume of EAP to the same volume of water (Ranganna, 1995). The results were expressed as g/cc. An average of five measurements is reported.

$$\text{Coefficient of rehydration: } \frac{\text{Wt. of EAP after rehydration X [100} - \text{Moisture (\%) in EAP before drying}}{\text{[Wt. of EAP taken for rehydration} - \text{Amount of moisture in dried EAP taken for rehydration] X 100}} \quad (3)$$

*Rehydration ratio:*

$$\text{Wt of EAP : Wt. of rehydrated EAP} \quad (4)$$

*Per cent water in the rehydrated EAP (Rehydration, %):*

$$\frac{\text{Wt. of rehydrated EAP – Dry matter content in the sample taken for rehydration}^{*}}{\text{Wt. of rehydrated EAP}} \text{ X 100} \quad (5)$$

*(Weight of EAP taken for rehydration − Moisture (g) in EAP before rehydration)

About 50 gm of dried paneer samples was powdered using mortar and pestle. The resultant powder was used for chemical analysis. Moisture, protein, fat, salt content and ash contents were determined according to AOAC (2007) procedures. Carbohydrate was calculated by difference. Ten grams of EAP powder in a beaker was stirred with 90 ml distilled water and pH measured by immersing combined glass-calomel electrode directly in a mixture using pH meter (Control Dynamic, APX 175 E/C, Bangalore India). Water activity ($a_w$) was measured using water activity meter (AquaLab 3TE, Decagon Devices Inc., Washington, USA). An average of four measurements was taken.

For determination of free fatty acid (FFA), a sample (10 g) was mixed with anhydrous $Na_2SO_4$ (100 g) and fat was extracted in 100 ml solvent mixture (chloroform: methanol = 2:1) and filtered. A known volume of chloroform: methanol extract was then washed three times with four to five volumes of distilled water in a separating funnel to remove non fatty acids that may have come from formulation ingredients. The FFA as percentage of oleic acid was estimated in washed chloroform: methanol extract using AOAC (2007) procedure. Lipid oxidation, thiobarbituric acid (TBA) was determined by the method of (Tarladgis *et al.*, 1960).

*Instrumental colour measurements*

Colour of dehydrated samples was measured using Hunter Colour Measuring System (Labscan XE, Hunter Associates Laboratory Inc., Virginia, USA) at 2° view angle. The Hunter colour measuring system was standardised with a white tile (L=90.71, a = -1.11 and b=0.63). Colour was described as coordinates, e.g. L, a and b (where L measures relative lightness, a relative redness, and b relative yellowness). The visual impression of colour is formed from hue [H=$\tan^{-1}$ (b/a)], chroma [C= ($a^2$+$b^2$)1/2] and lightness (Eagerman *et al.*, 1977). The measurements were used to calculate the hue angle (H) which represents the relative position of colour between redness and yellowness and chroma (C), which assesses the colour intensity. Colour stability was expressed as the rate of change (the slope of the fitted linear model) in L, H and C.

*Texture profile analysis*

Rehydrated EAP samples were subjected to texture profile analysis and shear force using a Texture Analyzer (LR5K, LLOYD Instruments Ltd, Hampshire, UK). The rehydrated samples were placed on the platform of texture analyzer. A cylinder plunger of 32 mm diameter attached to a 1 KN load cell and sample (13 mm) was compressed to 50% of its original height at a cross head speed of 100 mm/min twice in two cycles. The texture parameters viz. hardness (N), cohesiveness, springiness (mm), chewiness, and gumminess (N) were measured. Shear force was measured by applying a load of 50 Newton with a speed of 100 mm/min using triangle probe. The values were recorded based on the software, Nexigen version 6.0 (Lloyd Instruments Ltd, Hampshire, England) available with the instrument. The mean value of six readings for each texture profile is reported.

*Microbiological analysis*

A 10 g sample of dried EAP was placed in a sterile Stomacher bag containing 90 ml of sterile saline (0.85 % NaCl) solution and blended in Stomacher (Model SEWARD Stomacher 400, London, England). The blended samples were tested for standard plate counts (SPC), *Staphylococcus aureus*, *E. coli*, Coliform, spores and yeast and moulds, by spread plate and pour plate method as per APHA (2001) procedures.

*Sensory quality evaluation*

Dehydrated EAP samples were used for the preparation of curry. A traditional curry was prepared by using an optimum amount of spices and condiments. The curry contained chopped onion, ginger paste, garlic paste, green chillies, tomato puree, fresh coriander leaves, red chilly powder, coriander powder, turmeric powder and garam masala powder (a combination of spices like cardamom, clove, cinnamon, cumin and black pepper). The dried EAP were added in hot cooked curry. The curry with EAP was further cooked for 2-3 min. The EAP samples in curry were evaluated for sensory quality for appearance (shape retention), color, flavour, texture, juiciness and overall acceptability by 25 panelists using 9 - point Hedonic scale (Carpenter *et al*., 2000). (9=like extremely; 1=dislike extremely). The product was presented to panelists at 60 ± 5°C in coded white ceramic plates. Samples for evaluation were served separately in a well lit room on white enamel. The mean scores for each attributes are reported.

*Statistical analysis*

The experiment was carried out in 4 batches (n = 4). The mean of all parameters were examined for significance ($p \leq 0.05$) by analysis of variance (one way ANOVA) and mean separation and the significant effect was tested by Duncan's Multiple Range Test using software STATISTICA (Statsoft, 1999).

## Results and Discussion

*Product optimization*

The trial experiments for optimization of formulation indicated that a combination of wheat flour and rice flour for the preparation of EAP would result into the best quality of the product with respect to rehydration properties and texture of the rehydrated product. During optimization of ingredient levels, only the formulation that provided cube shaped product that did not disintegrate during further processing (drying, packing, rehydration or curry preparation), only was selected. It was also found that the levels of two binders (wheat flour and rice flour) in combination had an effect on texture and rehydration properties. Based on the textural properties of rehydrated product and judged by sensory evaluation, a ratio of wheat flour: rice, 3:1, was found optimum. The use of citric acid and malic acid in combination improved sensorily acceptability of the product. It was found that the foam formed during beating the egg white was better stabilized at low pH and also helped in uniform distribution of binders and other ingredients during cooking period. Further, the stabilized egg white froth did not allow the settling of ingredients during resting or molding time. Therefore, the pH of egg white was brought down to 5.9 by adding malic acid (0.4%) and citric acid (0.4%) in combination. It kept the foam elastic, but stable and can expand to its fullest when cooked (Anon, 2010a). Mleko *et al*. (2007) demonstrated that egg albumen at low pH leads to a substantial increase in foam firmness and gave the foam different properties than foams from untreated egg albumen. Vassilios *et al*. (2007) reported that the adhesiveness was highest at pH 5 for egg white. The egg white proteins showed the best foaming properties at pH 5 (Malgorzata *et al*., 2009). Fresh egg albumen pH was 8.6. Optimum levels of garlic powder (0.4%) and salt (1.5%) was added in the formulation for better flavour acceptability. The yield of the dried product was 60.00±2.16%. The product is shown in figure 1.

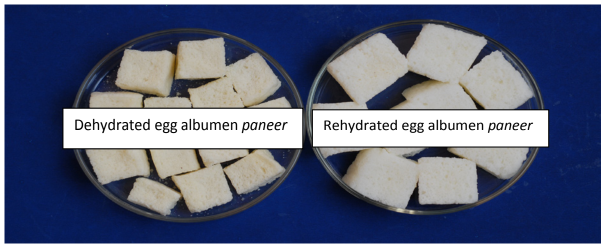



**Figure 1.** Egg albumen *paneer* dehydrated and rehydrated

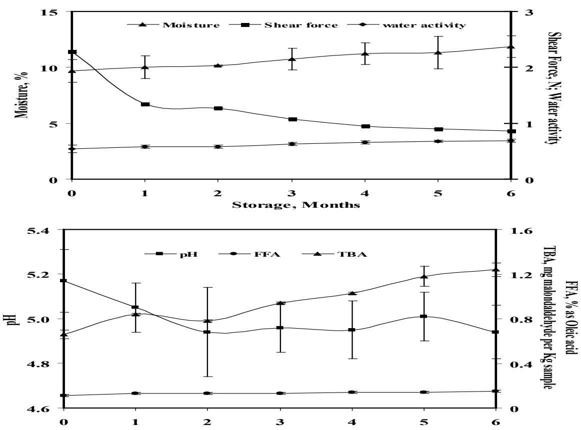
*Proximate composition*

Proximate composition and bulk density of EAP are given in (Table 1). The shelf stability of the product was achieved by keeping a low moisture content (9.68 ± 1.02%) and low water activity ($a_w$) (0.54 ± 0.02) (Figure 2). The protein content was 21.08 ± 1.35% and fat content was <1%. Shelf stable dried flake shaped egg products prepared from liquid egg using common salt, monosodium glutamate, garlic and onion extract had aw in the range of 0.20–0.50 with moisture content of 4.1–8.3% (Lee *et al*., 1998).

**Table 1.** Proximate composition, yield and bulk density of the dehydrated egg albumen *paneer*

| | |
|---|---|
| Moisture (%) | 9.68±1.02 |
| Ash (%) | 4.90±0.04 |
| Protein (%) | 21.08±1.35 |
| Total fat (%) | 0.49±0.03 |
| Salt (%) | 5.39±0.11 |
| Carbohydrate (%) | 58.46±1.6 |
| Yield after drying (%) | 60.00±2.16 |
| Bulk density (g/cc) | 0.11±0.00 |

(mean±SD, n=4)




**Figures 2.** Changes in quality parameters of the egg albumen *paneer* during storage at 27 ± 2°C (mean±SD, n=4)

**Table 2.** Changes in rehydration characteristics in egg albumen *paneer* during storage at 27 ± 2°C

| Storage, Months | Coefficient of rehydration | Rehydration, % | Rehydration ratio |
|---|---|---|---|
| 0 | 2.27±0.26[a] | 84.10±5.35[a] | 5.80±0.59[a] |
| 1 | 2.63±0.27[b] | 87.45±5.25[b] | 7.58± 0.29[b] |
| 2 | 2.43±0.24[b] | 86.23±2.93[b] | 6.60±0.70[c] |
| 3 | 1.99±0.15[c] | 81.46±5.30[c] | 4.94±0.37[d] |
| 4 | 2.01±0.16[c] | 81.67±7.38[c] | 5.12±0.61[d] |
| 5 | 2.12±0.09[ac] | 82.04±5.34[c] | 5.21±0.34[d] |
| 6 | 2.21±0.17[a] | 82.98±5.35[ac] | 5.27±0.79[d] |

a - d : Values in column with different superscripts differ significantly ($p < 0.05$) (mean±SD, n=4)

*Physico- chemical properties*

An average 123 ± 6% increase in volume of *paneer* was observed on rehydration. The increase in area could be due to very high rehydration ratio (1:5.8 ± 0.59) (Table 2) as observed in fresh samples. The determination of bulk density is of particular importance in the packaging of the products. The bulk density of the product was 0.11 g/cc (Table 1). Also on physical observation it was found the EAP had a very good porous structure which allowed more water absorption on rehydration. In general, the greater the density, the less pore space is available for water movement (Anon, 2010b). The porosity is also shown through photographs of the dried and rehydrated EAP (Figure 1).

Tests with respect to rehydration characteristics were more than satisfactory. Samples reached a high degree of rehydration. The effect of storage on product on rehydration (%), coefficient of rehydration and rehydration ratio are presented in (Table 2). Freshly (0 day) dried product absorbed less ($p\leq0.05$) water than 2 months stored product as indicated by rehydration of 84.10 ± 5.35% and 86.23 ± 2.93% respectively. The coefficient of rehydration initially was 2.27 ± 0.26, which decreased marginally ($p\geq0.05$) during storage. During storage of first three months there was a marked changes ($p\leq0.05$) in rehydration ratio but further storage the changes was non significant. Greater absorption of water by stored EAP was observed compared to fresh samples, could be due to it higher hydrophilic properties of egg albumen protein. Gennadios *et al*. (1996) reported the dried egg albumen films have highly hydrophilic properties.

The aw showed a gradual ($p\leq0.05$) ascending trend from initial values of 0.54 ± 0.02 - 0.69 ± 0.01 during storage for 6 months (Figure 2). Increased aw during storage was also reported for dehydrated chicken *kabab* mix (Modi *et al*., 2007) and for chicken nuggets (Lai *et al*., 1995). An increase in aw ($p\leq0.05$) during storage was observed could be, because of an increase ($p\leq0.05$) in moisture contents from 9.68 ± 1.02 to 11.87 ± 0.97 in the product stored for 6 months.

The fall in pH from 5.17 ± 0.14 to 4.94 ± 0.12 in dehydrated paneer (Figure 2) during the 6-month storage period was marginal. Freshly prepared products had low FFA values (as % oleic acid), 0.11 ± 0.01%, which gradually increased ($p\geq0.5$) to 0.0.15 ± 0.01% during 6 months of storage (Figure 2). An increase in FFA values in food products during storage because of lipase activity during storage has been reported by many authors; however, this increase did not increase rancidity in pork sausages (Fernandez and Rodriguez, 1991; Zalacain *et al*., 1995), and buffalo-meat burgers (Modi *et al*., 2003). However, the marginal increase in FFA could also be explained as the lipases might have been inactivated due to heat treatment of the product during processing. Camire *et al.* (1990) reported no toxicological effects of increased levels of FFA. Fritsch (1981) reported that the products of hydrolysis of oils/fats have no adverse effect on the nutritional quality of foods.

Oxidative rancidity measured by TBA values (mg malonaldehyde/kg sample) increased significantly ($p\leq0.05$) from 0.66 ± 0.04 to 1.24 ± 07 during the 6-month storage (Figure 2). Lai *et al*. (1995) and Martin et al. (2000) in chicken nuggets and Modi *et al*. (2003) in buffalo-meat burgers also reported marked ($p\leq0.05$) increase in TBA values during storage.

*Colour traits*

The colour attributes of products arise mainly from the pigmentation of raw material, with which they are made and the additives, which were used in the formulation. Instrumental colour of EAP was darker (L; $p\leq0.05$) after one month of storage (Table 3). Further storage attributed the lightness (L) of samples were unaffected ($p\geq0.05$). The least value of yellowness (b) ($p\leq0.05$) and redness (a) ($p\leq0.05$) was recorded after 6 months of storage. Fresh samples were more yellow ($p\leq0.05$) than 3 months stored samples, whereas, minor changes ($p\geq0.05$) in yellow units were observed during storage of EAP up to 2 months. Hue-angle values fluctuated in a narrow range of 67-71 during storage. However, chroma had higher ($p\geq0.05$) values after one month of storage and then it decreased ($p\leq0.05$) to 9.47 ± 0.22 after 6 months. Methods of processing (Pesek and Wilson, 1986), packaging conditions (Alvarez and Binder, 1984), degree of exposure to light (Kim *et al*., 2002) and interaction of ingredients (Osuna-Garcia *et al.*, 1997) may influence changes in color attributes of the products. In the present investigation, changes in the colour of EAP product were quite acceptable even after 6 months of storage at 27 ± 2°C despite changes ($p\leq0.05$) in the Hunter colour unit values of L, a and b.

**Table 3.** Changes in colour characteristics in egg albumen *paneer* during storage at 27 ± 2°C

| Storage, Months | Lightness (L) | Redness (a) | Yellowness (b) | Hue Angle (H) | Chroma (C) |
|---|---|---|---|---|---|
| 0 | 62.32±4.97$^{a}$ | 4.02±0.01$^{a}$ | 13.03±0.02$^{a}$ | 70.36±4.98$^{a}$ | 13.38±0.48$^{a}$ |
| 1 | 72.57±4.95$^{b}$ | 3.79±0.02$^{b}$ | 13.9±0.03$^{a}$ | 71.24±7.03$^{a}$ | 14.15±0.48$^{a}$ |
| 2 | 73.61±5.03$^{b}$ | 3.52±0.01$^{cd}$ | 12.64±0.01$^{a}$ | 70.65±7.49$^{a}$ | 12.87±0.51$^{b}$ |
| 3 | 72.63±4.98$^{b}$ | 3.73±0.02$^{b}$ | 11.45±0.03$^{b}$ | 68.18±7.55$^{b}$ | 11.86±0.35$^{c}$ |
| 4 | 73.60±6.30$^{b}$ | 3.62±0.01$^{c}$ | 10.55±0.0$^{c}$ | 68.27±5.42$^{b}$ | 11.30±0.38$^{c}$ |
| 5 | 72.22±5.43$^{b}$ | 3.54±0.05$^{cd}$ | 9.74±0.02$^{cd}$ | 68.26±3.22$^{b}$ | 10.29±0.16$^{d}$ |
| 6 | 72.26±5.67$^{b}$ | 3.46±0.02$^{d}$ | 8.92±0.03$^{d}$ | 67.06±3.44$^{c}$ | 9.47±0.22$^{e}$ |

a - e : Values in column with different superscripts differ significantly ($p < 0.05$) (mean±SD, n=4)

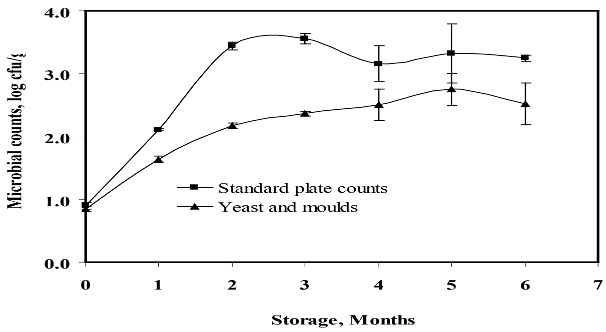
*Textural properties*

The effect of storage on the textural properties of EAP is presented in Table 4. Storage had a highly significant ($p \leq 0.05$) effect on the hardness of product; however, had not significant ($p \geq 0.05$) effect on the hardness when stored for one month. After 6 months, product had the lowest hardness (18.81 ± 2.54 N), while had the highest ($p \geq 0.05$) hardness in fresh (41.75 ± 4.78 N) and one month (39.03 ± 2.44 N) stored product. Storage and ingredients had not significant ($p \geq 0.05$) effect on the cohesiveness and chewiness of the EAP. Fresh EAP had the highest gumminess. However, storage period decreased ($p \leq 0.05$) gumminess of the product. Particularly, after 2 months of storage had a significant ($p \leq 0.05$) effect on the gumminess of EAP. Sample had marginal ($p \geq 0.05$) effect on springiness during storage of five months but, storage for six month had significant ($p \leq 0.05$) effect on the springiness. Adhesiveness was more ($p \leq 0.05$) in fresh samples compared to stored ones. Further, low adhesiveness could be due to rich foam formation during egg white beating for product preparation. However, low adhesiveness did not affect the product quality negatively. The variation in texture of EAP could be attributed to high rehydration ratio (more water absorption), which could impart a soft mushy texture to the product (Ahmed, 1990; Keeton, 1994).

The shear force decreased significantly ($p \leq 0.05$) (Figure 2) during storage complying with hardness and gumminess characteristics (Table 4). The shear force of fresh (0 day) rehydrated EAP had 2.28 ± 0.06 N, whereas, it decreased to 0.86 ± 0.03 N after six months of storage. One month storage had highly significant ($p \leq 0.05$) effect on the shear force of EAP, whereas, the effect was non-significant after 3 months of storage.

*Microbiological quality*

The SPC and yeast and mould counts fluctuated within the range of 0.90 ± 0.05 - 3.25 ± 0.05 and 0.84 ± 0.04 - 2.52 ± 0.33 log cfu/g, respectively (Figure 3) during storage for 6 months. SPC and yeast and mould counts increased at a faster rate up to 3 months storage. *Staphylococcus aureus*, *E. coli*, *Salmonella* and *Shigella*, however, could not be detected in any samples throughout 6 months storage. Lower counts of mesophiles (SPC), yeasts and moulds and absence of *Staphylococcus aureus*, *E. coli*, *Salmonella* and *Shigella*, observed in the EAP could be due to thermal processing, low aw values of the product, hygienic practices followed during processing and storage and antibacterial effects of garlic (Grohs and Kunz, 1999; Grohs *et al*., 2000). The results in the present investigation clearly indicate that the dehydrated EAP is microbiologically safe when packed in metalized polyester bags and stored at 27 ± 2°C for 6 months.




**Figures 3.** Changes in microbiological quality of the egg albumen *paneer* during storage at 27 ± 2°C (mean±SD, n=4) (TBA, thiobarbituric acid; FFA, free fatty acid)

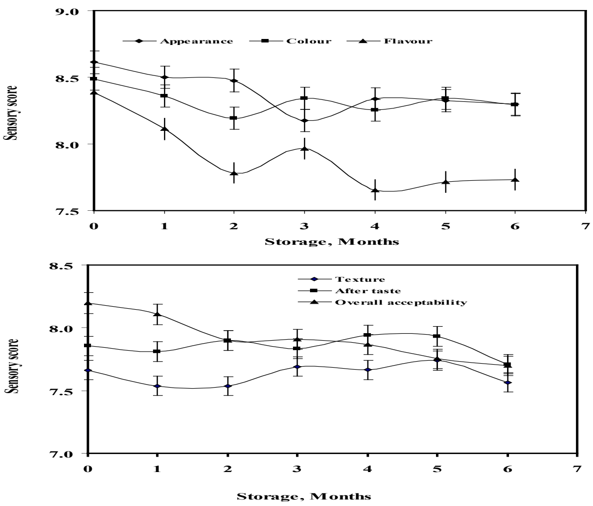
*Sensory quality*

Organoleptic characteristics scores are presented in (Figure 4). Sensory evaluation indicated that storage had effect ($p \leq 0.05$) on textural acceptability of the product. Sensory score of 0 day product (freshly prepared) for all quality attributes were in the range of 7.66 ± 0.77 - 8.61 ± 0.54 (like moderately to like extremely) which slowly decreased to 7.62 ± 0.47 – 8.30 ± 0.47 during storage for 6 months stored EAP. The sensory panel showed that the changes in appearance were marginal after 6 month of storage,

**Table 4.** Changes in textural profile analysis in egg albumen *paneer* during storage at 27 ± 2°C

| Storage, Months | Hardness (Newton) | Cohesiveness | Springiness (mm) | Gumminess | Chewiness | Adhesiveness (mm) |
|---|---|---|---|---|---|---|
| 0 | 41.75±4.78$^{a}$ | 0.23±0.01$^{a}$ | 3.10±0.03$^{a}$ | 9.12±0.27$^{a}$ | 0.03±0.01$^{a}$ | 0.05±0.01$^{a}$ |
| 1 | 39.03±2.44$^{a}$ | 0.23±0.01$^{a}$ | 3.07±0.03$^{a}$ | 8.76±0.20$^{a}$ | 0.02±0.01$^{b}$ | 0.05±0.02$^{a}$ |
| 2 | 19.57±2.43$^{be}$ | 0.22±0.01$^{a}$ | 3.63±0.04$^{b}$ | 6.91±0.18$^{b}$ | 0.01±0.01$^{b}$ | 0.12±0.01$^{b}$ |
| 3 | 21.30±2.87$^{c}$ | 0.26±0.01$^{b}$ | 3.37±0.03$^{c}$ | 6.29±0.31$^{c}$ | 0.02±0.01$^{b}$ | 0.04±0.01$^{a}$ |
| 4 | 20.4±2.30$^{bc}$ | 0.23±0.01$^{a}$ | 3.13±0.02$^{a}$ | 6.02±0.25$^{cd}$ | 0.01±0.01$^{b}$ | 0.08±0.01$^{c}$ |
| 5 | 19.21±2.84$^{bd}$ | 0.22±0.01$^{a}$ | 2.95±0.02$^{a}$ | 5.76±0.21$^{de}$ | 0.02±0.01$^{b}$ | 0.04±0.01$^{a}$ |
| 6 | 18.81±2.54$^{d}$ | 0.21±0.01$^{a}$ | 2.62±0.02$^{d}$ | 5.33±0.16$^{e}$ | 0.01±0.01$^{b}$ | 0.01±0.01$^{d}$ |

a - e : Values in column with different superscripts differ significantly ($p < 0.05$) (mean±SD, n=4) though marked change in rehydration properties was observed. The loss of egg flavour ($p \leq 0.05$) in stored product was observed by panelist. A gradual increase in FFA and TBA values explains the descending trends in ratings for sensory quality attributes. Similar observations have been reported for beef patties (Bullock *et al*., 1994), for buffalo burgers (Modi *et al*., 2003) and for egg loaf (Yashoda *et al*., 2004). In the present investigation, the descending trends in sensory scores over the storage period, however, were not significant ($p \geq 0.05$) and the EAP was sensorilly acceptable in the range of like moderately to like very much (7.58) based on hedonic scale. The panellists fail to award higher score (like extremely) to the EAP samples. The sensory data revealed that rehydrated EAP, are of first quality with closest possible to fresh ones.




**Figures 4.** Changes in sensory score of the egg albumen *paneer* during storage at 27 ± 2°C (mean±SD, n=4)

## Conclusion

A convenience and ready-to-use natural product from egg albumen was prepared. The quality characteristics of the product are reported in this study. The product packed in metalized polyester pouch is nutritionally superior and had a shelf life of 6 months under ambient conditions (27 ± 2°C). As the product is more similar to milk paneer, a traditional product, it has better consumer acceptability. In addition, the product does not contain any added preservative and is low in fat content (<1%). Due to hurdles in the form of low water activity the product is stable at ambient conditions. The product can be used as such by adding in soups or in the preparation of different varieties of traditional rice preparations. Also the EAP can be used for enrichment of nutritional quality by adding in baby foods. The product can be recommended under various nutritional programme or as a health food, because, of its well acceptance, quality protein and shelf stability in nature.

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