

Physico-chemical, microbiological and sensory characteristics of egg based snack food

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A process for shelf stable, ready-to-eat nutritionally rich egg based snack food referred to as egg crunchy bite (ECB) was developed. The formulation contained mixing of liquid egg (~77%) with a mixture of different binders (~23%); followed by steam cooking, dicing, drying, roasting and seasoning. All the samples were packed in metalized polyester pouches, stored at ambient temperature (25 ± 2 °C) and analyzed for quality characteristics. The protein and total fat contents of ECB without garlic (ECB-C) was 15.48 ± 1.04 and $25.26 \pm 1.03\%$ respectively. The ECB with garlic (ECB-G) showed insignificant changes ($p > 0.05$) in TBA and iodine value during storage. The carotenoid stability was better ($p > 0.05$) in ECB-G as compared to ECB-C. Both the product showed insignificant changes ($p > 0.05$) in colour characteristics and breaking force during storage. The in-vitro digestibility of ECB products was of 71% of the total protein in the sample. Sensory evaluation revealed that overall liking had positive responses of, 84% and 79% for ECB-C and ECB-G respectively after six months storage. The product had relatively good amounts of calcium, iron, zinc and vitamin A, thus making it nutritionally beneficial. Yeast and moulds, *E coli*, and *Salmonella* were not detected in both the samples throughout the storage period.

Keywords: Liquid egg, Egg products, Crunchy bites, PDCAAS value, Carotenoid

Introduction

Snack foods are items eaten for pleasure and during relaxation. These include deep fried potato chips, sticks, rings, nuts, fried grams etc. and represent a substantial share of the snack food market. US retail sales of snack foods rose to about \$64 billion in 2010, and projects to approach \$77 billion by 2015, a total increase of over 20%¹. 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 Willense². Information is available on different egg products, such as egg coated potato³; premixed flavoured egg product⁴ and formulated fried egg⁵. Whereas, under egg based snack foods, the researchers have developed egg flakes containing monosodium glutamate and spice extracts⁶; egg white chips containing stabilizers and flavouring⁷; egg chips containing millet flours⁸. Apart from above mentioned egg based snack foods, reasonable volume of research has been carried out on vegetable based snack foods

especially on potato chips, potato sticks or crackers. Most of them are poor in nutritional quality and contains high fat. All the types of snacks based on potato, cereals, and pulses produced by the leading manufacturers are rich in fat (26-52%)⁹. Present trends in health awareness of the population demand for low fat snack foods. Several investigators have used edible coating to reduce fat content in fried snack foods¹⁰⁻¹². Coating potato chips with egg white proteins resulted, 12% reduction in oil uptake¹³. Quality aspects of extruded snack food have been reviewed by Anton et al.¹⁴.

A snack food from egg with low fat contents, compared with majority existing snack foods, would definitely provide a newer taste with all nutritional benefits, and is to be proved a new dimension in the consumer's choice. The product egg crunchy bite (ECB) is a novel product and first of its kind. No information is available on such a product or any distantly related product in the literature. Our objective of this work was to produce a ready to eat egg based nutritionally rich with comparatively low fat snack product and to study storage quality at ambient temperature (25 ± 2 °C) and consumer acceptability of final product.

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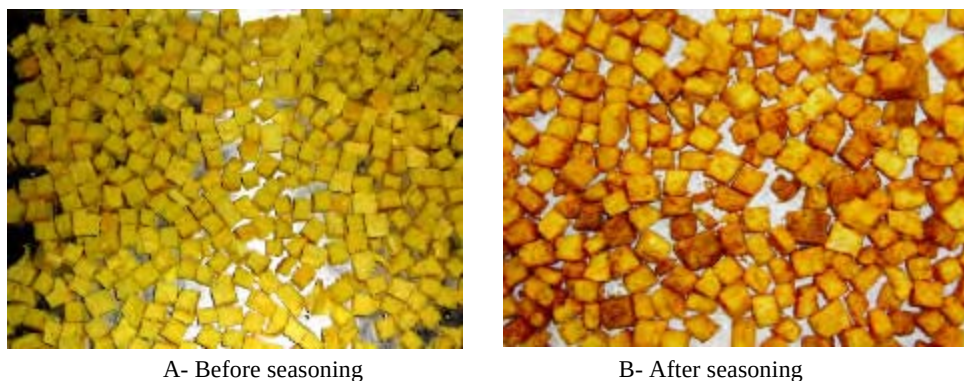


Fig. 1—Egg crunchy bites A- Before seasoning B- After seasoning

Experimental Methods

Product preparation

Hen eggs were procured from local market. A batch of 90 eggs weighing in the range of 4500-5000 g was broken over a sieve to separate albumen and yolk. Egg albumen (49%) and egg yolk (28%) were mixed with 23% of binders consisting of wheat flour (23%), rice flour (43%), corn flour (23%), maltodextrin (2.3%), soya protein (1.16%), malic acid (0.28%), citric acid (0.28%), guar gum (2.3%) and common salt (4.6%) in a Hobart Padel mixer (M-50, USA) to obtain a batter. The batter was transferred to rectangular stainless steel moulds of 22×9×9 cm dimension, lined with polypropylene sheet to avoid sticking to the sides of mould during cooking. The product in mould was steamed at atmospheric pressure for 35 min (internal temperature 86 ± 2 °C) to obtain a solidified product, followed by cooling at ambient temperature (25 ± 2 °C) for 30-45 min, conditioning under chilled storage ($4-6$ °C) for overnight and finally it was cut into cubes ($1 \times 1 \times 1$ cm). The resultant product was dried in a cross flow dryer [C.M. Equipments & Instruments (India) Pvt. Ltd, Bangalore, India] at $70-75$ °C for 4 hrs to obtain dried cubes. The dried cubes were allowed to cool, and was processed further.

Roasting and seasoning

The desirable texture (crispness) and flavour was obtained by roasting and seasoning. The dried product was roasted in a roaster (Gansons, Model GMP-FT, Mumbai, India) at $80-85$ °C for 6 minutes till light golden brown colour was obtained. The pre-heated ($80-85$ °C) refined sun flower oil (8%) was sprayed over the roasted product and roasting was continued (2 min) till a uniform oil coating was noticed. Further the product was seasoned by sprinkling seasoning mix (12%) and continued mixing for another 2 minutes. The seasoning mix was prepared

by mixing mango powder (30%), red chilly powder (20%), cumin powder (20%), sea salt (16%), rock salt (8%), black pepper powder (1.40%), ginger powder (1.30%), turmeric powder (0.40%), and citric acid (0.24%) for 2–3 min in a mixer. After roasting and seasoning, the product was cooled to ambient temperature. The resultant product was named egg crunchy bite (ECB). The photographs of the product before seasoning and after seasoning are presented in Fig. 1. Product processing details are listed in CSIR-CFTRI process know-how.

The product made without garlic in formulation was referred as egg crunchy bite control (ECB-C). Whereas, to study the oxidative changes during storage, garlic powder (2%) as a natural antioxidant was incorporated while mixing the batter ingredients and referred as egg crunchy bite with garlic (ECB-G).

Storage studies

The product was packed in metalized polyester (12μ PET / 9μ Al foil/ 37.5μ LDPE), bags of 20 g capacity each and stored under standard conditions (25 ± 2 °C, $65\% \pm 2\%$ RH). The stored products were drawn periodically for six months for quality evaluation. The keeping quality assessment of the products was based on moisture content, texture – crispness, sensory, microbiological and rancidity parameters.

Physical and cooking characteristics

The % cooking yield of the product was determined by weighing the egg product before and after cooking. The percent dehydration loss of the product was determined by weighing the weight of egg product before and after drying. Bulk density of the product was determined by filling the product to the rim of 500 mL graduated cylinder and weighing the sample filled in

cylinder. The results were expressed as g/cc (mass/volume)¹⁵. The percent size reduction in dehydrated ECB as compare to the finished product (i.e., dehydrated ECB after roasting and seasoning) was determined by measuring the area of ECB before roasting and after roasting. An average of eight measurements is reported for all physical characteristics.

Proximate composition, pH and water activity (a_w)

Three packets of dried ECB samples were powdered using mortar and pestle. The powder was used for chemical analysis. Moisture, protein, fat, salt and ash contents were determined according to AOAC procedures¹⁶. Carbohydrate was calculated by difference. Ten gram of ECB powder was mixed in a beaker consisting 90 mL distilled water and pH was measured by immersing combined glass-calomel electrode directly in a mixture using APX 175 E/C pH meter (Control Dynamic, Bangalore, India). Water activity (a_w) was measured using an AquaLab 3TE water activity meter (Decagon Devices Inc., Washington, USA). An average of four measurements was taken.

Minerals and vitamin

The mineral contents viz; calcium, iron and zinc were estimated by AOAC procedures¹⁶ using Shimadzu AA-6701 atomic absorption spectrophotometer (Shimadzu, Kyoto, Japan). Vitamin A was estimated by HPLC method as described by Sangeetha and Baskaran¹⁷. The HPLC system LC-10AVP (Shimadzu, Kyoto, Japan) was equipped with shimadzu photodiode array detector (SPD-M20A). The vitamin was separated on phenomenon C₁₈-OSU column (150mmX4.6mm; 5 μ m). The peak identifying of vitamin A was confirmed by its characteristic spectrum. Quantification of vitamin was evaluated by comparing its peak area with standard. The minerals and vitamin were estimated in control samples only.

Protein digestibility corrected amino acid score (PDCAAS)

In vitro digestibility of the prepared ECB was determined by the method of Akeson and Stahman¹⁸. Pepsin followed by pancreatin digestion was carried out using sample equivalent to 100mg protein. Initially the sample was digested with 1.5 mg pepsin (Sigma, USA) in 15 mL 0.1N HCl (pH 2.5) at 37 °C for 3h. After neutralization with 7.5 mL of 0.2N NaOH, the digestion was continued using 4mg pancreatin (Sigma, USA) in 7.5 mL of phosphate buffer (pH 8.0) at 37 °C for an

additional 24h. These enzymes were inactivated using 10% tri-chloroacetic acid. The digest were filtered and quantitatively made up to 100 mL with distilled water. *In vitro* protein digestibility of the product was expressed as the per cent of total protein present in the digest. Amino acid contents were calculated based on reported values of the ingredients¹⁹. Protein digestibility corrected amino acid score (PDCAAS) was calculated as per Sarwar & Mc Donough²⁰ by determining the un-corrected amino acid score using the reference protein requirement levels (mg per gram of crude protein)—for pre-school (2–5 years), school (10–12 years) children along with adults—prescribed by FAO/WHO²¹. The un-corrected amino acid score is calculated by dividing the mg of essential amino acid in 1g of test protein by milligram of amino acids in 1 g of the reference protein, which is the requirement for a particular group. Finally, multiplying the lowest of the un-corrected amino acid scores by the digestibility value yields the PDCAAS score²². PDCAAS values were calculated for control samples.

Rancidity parameters and carotenoid contents

Free fatty acid (FFA), a sample of ECB (10 g) was mixed with anhydrous Na₂SO₄ (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 (% oleic acid) and Iodine value (g I₂/100g oil) and PV, meqO₂/kg was determined by AOAC procedure¹⁶. Thiobarbituric acid (TBA) was determined by the method of Tarladgis et al.²³. The carotenoid contents of the product were estimated by the method as described by Simpson et al.²⁴.

Instrumental colour measurements

Colour of ECB samples were measured using Labscan XE Hunter Colour Measuring System (Hunter Associates Laboratory Inc., Virginia, USA) at 2° view angle. The Hunter colour measuring system was standardized with a white tile (L=90.4, a =-0.98 and b=1.05). Colour was described as coordinates, e.g. L, a and b (where L measures relative lightness, a relative redness, and b relative yellowness).

Texture profile analysis

Breaking force of the ECB was conducted according to the method described by Veronica et al.¹⁵ with slight

modification using the Lloyd LR5K Texture Analyzer (LLOYD Instruments Ltd, Hampshire, UK) as described by The sample was placed on the platform of texture analyzer and a 3 point bend plunger type of 10 mm was attached to 1 kN load cell and sample (8 mm cube) was applied for breaking force (maximum force [N] required to break the sample) at a cross head speed of 100 mm/min. 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 ECB was placed in a sterile stomacher bag containing 90 mL of sterile saline (0.85 % NaCl) solution and blended in Stomacher (Stomacher 400, SEWARD, London, England). The blended samples were tested for standard plate counts (SPC), *Staphylococcus aureus*, *E. coli*, *Salmonella* and yeast and molds by spread plate and pour plate method as per APHA procedures²⁵.

Sensory quality evaluation

The ready to eat ECB samples were evaluated for sensory quality by consumers (panellists, n=30) using 9-point Hedonic scale²⁶ for a set of attributes: appearance, flavour, texture and overall liking, where 9=like extremely, 8= like very much, 7=like moderately, 6=like slightly, 5=neither like nor dislike, 4=dislike slightly, 3=dislike moderately, 2=dislike very much 1=dislike extremely. The consumer acceptability was carried out for six months stored samples after confirmation of the microbiological safety of products. Consumers were randomly selected and were briefly educated about the product characteristics. As noted by Schutz²⁷ consumers were typically asked to give judgments on how much they like or dislike the products. Two samples were served to each consumer in monadic order. Drinking water was provided for palette cleaning between samples. Serving order was randomized so that approximately 50% of the consumers evaluated the control ECB-C sample first and 50% of the consumers evaluated the garlic incorporated ECB-G sample first.

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 (ANOVA) and mean separation and the significant effect was tested

Table 1—Proximate composition (%) of egg crunchy bites

	ECB-C	ECB-G
Moisture	2.07±0.11	2.31±0.18
Protein	15.48±1.04	14.93±0.89
Total fat	25.26±1.03	25.36±1.58
Ash	6.57±0.43	6.14±0.27
Salt	4.36±0.21	4.29±0.28
Carbohydrate	45.63±2.71	46.64±3.11

Values are mean±SD (n=4)

by Duncan's Multiple Range Test using software STATISTICA²⁸.

Results and discussion

Physical and cooking characteristics

An average of 97% cooking yield was obtained after steam cooking the product. The loss of moisture during dehydration was calculated as dehydration loss and was found to be 41±2%. The bulk density of the coated product was 0.21g/cc. An average 20% reduction in size of ECB was observed as compared to the finished ECB. The aforesaid findings were same for ECB-C and ECB-G products. (Data of physical characteristics not presented in tables).

Proximate composition

Proximate composition of ECB-C and ECB-G are given in Table 1. The ECB-C contained 2.07% moisture, 15.48% protein, 25.26% fat and 6.57% ash. The compositional changes in ECB-C and ECB-G was non significant. Protein content was markedly high whereas, total fat in the product was low compared with common snack foods available in market. Wide variation in chemical composition of different well known traditional snacks produced viz., *aloo bhujia*, *boondi*, corn flakes, potato sticks and salted pea nuts etc contained in the range of 39.5-51.9% fat and 3.6-14.7% protein⁹. Snack foods like potato chips, potato sticks, corn based extruded products, oil popped popcorns etc contained high fat (30-43%) contents and low in protein (4-8%)²⁹. The ECB as a snack food have nutritional advantage of being egg protein and low in fat content compared with other commercially available snack foods.

pH, Moisture and a_w

The pH of ECB-C and ECB-G was decreased ($p \leq 0.05$) gradually from 5.53±0.18 to 5.40±0.39 and from 6.67±0.10 to 5.58±0.30 when stored for 6 months, respectively (Table 2). Water activity (a_w) of ECB-C

Table 2—Physico chemical and Hunter colour traits changes of egg crunchy bites during storage under ambient conditions (25±2 °C)

	ECB-C				ECB-G			
	Storage, months							
	0	2	4	6	0	2	4	6
pH ^{ns}	5.53±0.18 ^a	5.51±0.15 ^a	5.42±0.10 ^a	5.40±0.39 ^a	5.67±0.10 ^a	5.60±0.27 ^a	5.67±0.29 ^a	5.58±0.30 ^a
Moisture (%)	2.07±0.11 ^a	2.29±0.19 ^b	2.32±0.11 ^b	2.31±0.08 ^b	2.31±0.23 ^a	2.64±0.18 ^b	2.73±0.19 ^b	2.75±0.16 ^b
a _w	0.25±0.01 ^a	0.32±0.02 ^b	0.33± 0.01 ^b	0.34± 0.02 ^b	0.34± 0.02 ^a	0.38± 0.02 ^b	0.40± 0.03 ^b	0.40± 0.02 ^b
FFA content, %	3.38±0.10 ^a	3.35±0.40 ^a	3.75±0.35 ^b	3.70±0.26 ^b	3.25±0.29 ^a	3.55±0.50 ^b	3.60±0.63 ^b	3.66±0.20 ^b
oleic acid								
IV, g I ₂ /100 g oil	112.68±5.27 ^a	100.51±9.68 ^a	92.97±6.12 ^b	89.11±7.29 ^b	103.89±8.57 ^a	100.67±5.03 ^a	101.10±8.57 ^a	97.42±4.78 ^a
PV, meqO ₂ /kg	143.56±9.78 ^a	154.25±11.61 ^a	93.50±4.43 ^b	110.75±4.92 ^c	139.98±8.38 ^a	146.33±10.88 ^a	84.50±11.27 ^b	94.66±6.51 ^b
TBA, mg	2.43±0.66 ^a	2.56±0.29 ^a	2.72±0.86 ^b	3.72±0.18 ^c	2.26±0.49 ^a	2.48±0.34 ^a	2.46±0.36 ^a	2.66±0.33 ^b
malonadehyde/ kg								
Lightness, L	56.22±5.34 ^a	52.97±5.30 ^a	47.82±5.25 ^b	44.25±4.99 ^b	62.36±2.69 ^a	59.39±4.08 ^a	57.96±2.91 ^b	53.75±2.40 ^b
Redness, a	9.62±0.34 ^a	9.24±0.23 ^a	8.48±0.15 ^b	6.80±0.25 ^b	8.61±0.31 ^a	8.71±0.34 ^a	7.42±0.43 ^b	6.27±0.37 ^b
Yellowness, b	28.95±0.58 ^a	28.06±0.87 ^a	31.47±0.76 ^b	32.90±0.33 ^b	30.70±0.35 ^a	28.97±1.83 ^a	33.83±2.66 ^b	35.37±1.03 ^b

Values are mean±SD (n=4); ns: non significant;

a - c : Values in row of the same product with different superscripts differ significantly (pd^{ns}0.05)

ECB-C Egg crunchy bite (control); ECB-G Egg crunchy bite (with added garlic)

and ECB-G was increased ((p≤0.05) gradually from the initial value of 0.25 ±0.01 to 0.34 ±0.02 and from 0.34±0.02 to 0.40±0.02 respectively, when stored for 6 months. The differences were significant during storage period of 2 months and non significant on subsequent storage. Increase in a_w during storage could be due to increase (p≤0.05) in moisture content.

Minerals and vitamin

A good amount of calcium 129.49±8.33 mg/100g, iron 5.94±0.50 mg/100g and zinc 2.18±0.22 mg/100g was present in the product, while, vitamin A was 25.3±1.88 mg retinol/100g (Table 3).

Protein Digestibility Corrected Amino Acid Score (PDCAAS)

The calculated values of amino acid composition (Table 4) of the samples indicated the presence of essential amino acids like leucine (8.17%), lysine (6.69%), valine (5.54%), and isoleucine (4.98%) thus, making it nutritionally beneficial. Difference in protein digestibility of various foods arise from inherent difference in the nature of the food protein, presence of non-protein constituents or from processing conditions that alter the release of amino acids from proteins by processes^{30,31}. The higher digestibility, (71.04%) further proves quality protein in product. The PDCAAS values for the product were highest (1.00) for adults whereas; it was 0.82 and 0.89 for pre-school, (2-5 years) and school, (10-12 years)

Table 3—Minerals and vitamin of egg crunchy bites (ECB-C)

Calcium, mg/100g	129.49±5.43
Iron, mg/100g	5.936±0.31
Zinc, mg/100g	2.179±0.13
Vitamin A, mg retinol/100g	25.3±1.43

Values are mean±SD (n=4)

children respectively. The PDCAAS scores for a variety of food proteins include 1.0 (casein, soy protein isolate), 0.92 (beef protein), 0.68 (kidney beans) and 0.40 (whole wheat). This indicated the potential of egg crunchy bites as a food in nutritional programmes.

Changes in Free Fatty acid (FFA)

The amount of FFA in product was measured to indicate the extent of its deterioration due to hydrolysis or oxidation of fatty acid double bonds. The initial FFA values of the products were marginally different (3.38±0.104 and 3.25±0.292 for ECB-C and ECB G, respectively). The total increase in FFA value from 0 day to six months storage was found to be about 9.0% (p≤0.05) in ECB-C, whereas, it was about 12% in ECB-G (Table 2). In most of the foods, the amount of FFA produced by hydrolysis is too small to affect the quality of the food. Generally, adverse effects are due to oxidation of unsaturated fatty acids. Because the determination of FFA by titration does not differentiate between acids formed by oxidation and those by

hydrolysis, the increase in FFA is a poor measure of fat deterioration. However, it could be a good indicator of the extent of fat abused in the product. An increase in FFA values in food products during storage is well documented, and this activity did not increase rancidity of food products prepared by using spice ingredients like pork sausage^{32,33}. Sallam et al.³⁴ reported that the inclusion of garlic powder in product formulation provides antioxidant protection to the products.

Changes in Iodine value (IV)

Table 2 shows the change in IV of the product during storage. A decrease in IV indicates the degree of unsaturation of the fats. A decrease in IV can be attributed to the destruction of double bonds by oxidation and polymerisation. Changes in IV over the 6 months storage from 0 day for ECB-C 112.68 ± 5.27 – 89.11 ± 7.29 were larger than that of ECB-G 103.89 ± 8.57 – 97.42 ± 4.78 (Table 2). Lesser changes were found in ECB-G had a longer induction period since there were no significant changes ($p \leq 0.05$) for the first four months of storage of the product. In ECB-C, however, the changes in the IV were significant ($p < 0.05$) during the first month of storage, indicating shorter induction periods. This indicated that ECB-G was less susceptible to oxidation than ECB-C.

Changes in Peroxide value (PV)

There was initial increase ($p \leq 0.05$) in PV of ECB-C, from 0 days to 2 months storage after which it decreased, whereas in ECB-G the PV decreased ($p \leq 0.05$) in first two months (Table 2). The rate of change in PV with time of 6 months storage time for the ECB-C and ECB-G were 22.85% and 32.35% respectively. Peak values for the PV were attained as; for ECB-C, 154.25 ± 11.61 meqO₂/kg and for ECB-G, 146.33 ± 4.39 meqO₂/kg after 2 months of storage. Increase in PV in product showed the fats to be unstable to oxidative degradation. This was largely due to the high amounts of unsaturated fatty acids in the egg. The PV decreased in both products after the peak was reached. Though the PV peak for ECB-C and ECB-G were reached after 2 months but the increase in PV for ECB-C was 7.44%, whereas, it was 4.56% in ECB-G. The difference in rate of increase in PV could be because the presence of garlic in ECB-G. The fact as also been proved by researchers as garlic acts as an antioxidants³⁴. PV alone is not a suitable parameter to assess the extent of fats and oil deterioration. Increase in the PV during storage period

indicates increased formation of peroxides due to oxidation. However, peroxides are unstable and as fat deterioration continues the hydroperoxides decomposes forming carbonyl and aldehydic compounds causing the peroxide value to decrease³⁵. That is why the amount of peroxides formed in fatty foods during storage cannot be used to estimate the extent of deterioration.

Changes in thiobarbituric acid (TBA)

The oxidative rancidity measured by TBA values (mg malonadehyde/Kg) also showed gradual ascending trend from initial values of 2.43 ± 0.66 to 3.72 ± 0.18 and 2.26 ± 0.49 to 2.66 ± 0.33 during storage of ECB-C and ECB-G respectively for 6 months (Table 2). The difference in TBA values due to the presence of garlic in formulation during storage was marginal ($p \leq 0.05$). This could also be due to the presence of spice coating to product and presence of carotenoid providing antioxidant protection to the product^{36,37}.

Instrumental colour characteristics and carotenoid

After processing, no visible colour difference was observed in both the products. The Hunter colour units of the products during storage are given in Table 2. Hunter colour revealed that the 'L' (lightness) and 'a' (redness) values of ECB-C decreased ($p \leq 0.05$) consistently during storage of the products for six months. However, 'a' value decreased ($p \leq 0.05$) up to 4 months which then remained almost constant for six months. The 'b' (yellow) unit of the product gradually increased ($p \leq 0.05$) from 28.95 ± 0.58 to 37.50 ± 3.32 during the storage of six months. On the other hand the Hunter colour units for ECB-G, 'L' values marginally fluctuated ($p \leq 0.05$) from 62.98 ± 2.90 to 59.71 ± 2.32 whereas 'a' decreased ($p \leq 0.05$) from 9.83 ± 0.89 to 8.42 ± 0.43 in first two months of storage there after the changes were marginal ($p \leq 0.05$) for six months. The 'b' values fluctuated ($p \leq 0.05$) in the narrow range of 30.70 ± 0.35 – 28.07 ± 1.86 during storage for six months. During storage ECB-C resulted into significantly lower 'L' and 'a' values and increased 'b' values compared to ECB-G. Changes in colour units are reported to be dependent on the method of processing³⁸, degree of exposure to light³⁹, storage temperature⁴⁰ and interaction of ingredients⁴¹. There was no definite trend change in Hunter values during storage of fried egg yolk cubes⁴². In the present investigation, visual colour appearance of both the products was quite acceptable even after 6 months storage despite changes in instrumental chromatic attributes (L, a and b values).

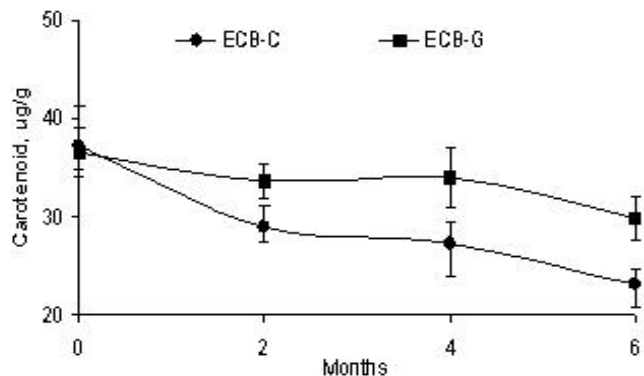


Fig. 2—Changes in total carotenoid of egg crunchy bites during storage under ambient conditions ($25\pm 2^{\circ}\text{C}$). Values are mean $\pm$ SD (n=4)

Noticeable effects were observed in total carotenoid content of ECB-C and ECB-G during storage is presented in Fig. 2. The total changes in ECB-C were much higher ($p\leq 0.05$) than ECB-G. After 2 and 4 months of storage, the carotenoid values of ECB-C (29.04 ± 2.24 , 27.16 ± 2.38 µg/g, respectively) was found to be significantly lower ($p\leq 0.05$) than ECB-G (33.62 ± 1.70 , 34.03 ± 3.11 µg/g, respectively). However, this decrease among the product was non-significant ($p\leq 0.05$). Further it was observed that the rate of decrease was gradual for ECB-C and ECB-G and has decreased ($p\leq 0.05$) about 38% and 18% respectively at the end of six months storage. Wenzel *et al.*⁴³ reported that the contents of carotenoid in the egg yolk powder were significantly lower on storage. Similar observations were made by Tavarini *et al.*⁴⁴ during storage of Kiwi fruit.

Textural property

The textural properties of samples with garlic and without garlic in terms of crispiness were evaluated by measuring breaking force. It was found that the breaking force of ECB-C (23.39 ± 2.13 N) was lower ($p\leq 0.05$) compared to ECB-G (25.58 ± 1.71 N) and similar trend was observed during storage of the products (Fig. 3). The difference in breaking force in the beginning could be due to difference in moisture content (2.07 ± 0.10 N) in ECB-C and ECB-G (2.31 ± 0.23 N) on 0 day. However, storage did not affect the breaking force significantly ($p\leq 0.05$). The breaking strength of extruded corn meal snack foods was significantly affected by moisture⁴⁵ and by the levels of fat and protein¹⁵.

Microbiological quality

SPC counts of ECB-C and ECB-G fluctuated within the narrow range of 4.4–3.3 and 3.96–2.09 log cfu/ g,

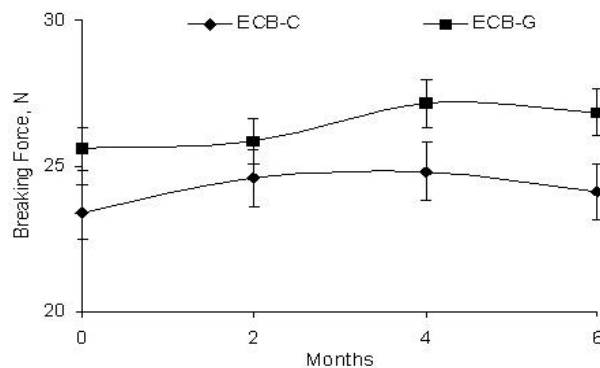


Fig. 3—Changes in breaking force of egg crunchy bites during storage under ambient conditions ($25\pm 2^{\circ}\text{C}$). Values are mean $\pm$ SD (n=4)

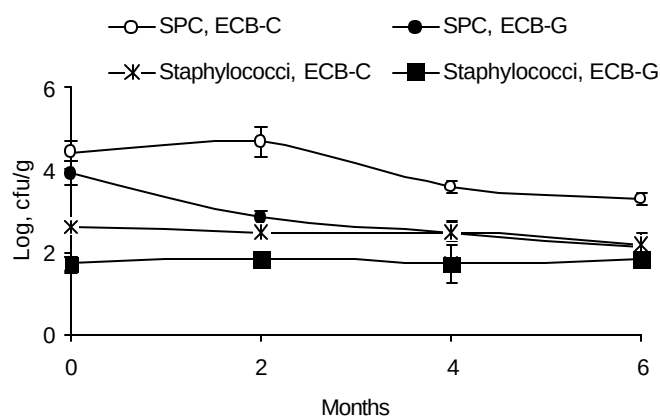


Fig. 4—Changes in microbial counts of egg crunchy bites during storage under ambient conditions ($25\pm 2^{\circ}\text{C}$). Values are mean $\pm$ SD (n=4)

respectively (Fig. 4) during storage of 6 months. The decrease in SPC of ECB-G during storage was 1 log cycles after 1 month and the counts then noticeably ($p\leq 0.05$) decreased after 6 months to 2.0 log cfu/g. On the other hand, staphylococci counts in ECB-C did not change during the storage period. However, this counts in ECB-G initially were 1.76 log cfu/g which markedly ($p\leq 0.05$) decreased after 1 month of storage and the counts remains <1 log cfu/g after storage of 6 months. Yeast and moulds, coliforms and *Salmonella* were not detected in any samples throughout the storage of 6 months. Lower counts or absence of pathogenic organisms like *Salmonella*, *Shigella* *Staphylococcus aureus* in the product could be due to thermal processing, low a_w and hygienic practices followed during processing. The least counts in ECB-G could be due to the antibacterial effects of garlic^{46,47}. The results in the present investigation clearly indicate that the egg crunchy bites is microbiologically safe when packed in metalized

Table 4—Amino acid composition and protein digestibility corrected amino acid score (PDCAAS) values of egg crunchy bites (ECB-C)

Essential amino acids	Content (mg g ⁻¹ crude protein)	Uncorrected amino acid score		
		2-5 yrs	10-12 yrs	adults
histidine	23.90	1.26	1.26	1.49
threonine	39.01	1.15	1.39	4.33
valine	55.41	1.58	2.22	4.26
cysteine+methionine	39.24	1.57	1.78	2.31
isoleucine	49.81	1.78	1.78	3.83
leucine	81.67	1.24	1.86	6.28
tyrosine+phenylalanine	80.11	1.27	3.64	4.22
lysine	66.87	1.15	1.52	4.18
Invitro digestibility, %	71.04			
PDCAAS		0.82	0.89	1

Standard PDCAAS values (mg g⁻¹ crude protein) as per FAO/WHO (1985) for histidine, threonine, valine, cystine + methionine, isoleucine, leucine, tyrosine + phenylalanine and lysine are —19, 34, 35, 25, 28, 66, 63 and 58 (for 2–5 year olds); 19, 28, 25, 22, 28, 44, 22 and 44 (10–12 year olds) and 16, 09, 13, 17, 13, 19, 19 and 16 (adults), respectively

Table 5—Sensory score means for consumer acceptance testing of egg crunchy bites after six months storage under ambient conditions (25±2 °C)

Sensory Attribute	ECB-C	ECB-G
Overall liking -ns	7.23 ±1.80	7.11± 1.53
Flavour liking -ns	7.20 ± 2.11	7.10 ± 1.79
Texture liking -ns	7.50 ± 1.65	7.34 ± 2.03
Appearance likings -ns	6.37± 1.82	6.27± 1.58

ns- non significance Values are Mean±SD

polyethylene bags and stored at 25±2 °C for 6 months. Further, products prepared with egg are likely to be prone for microbial spoilage, but microbiological studies have proved it to be safe, thus making it an excellent and novel product.

Sensory evaluation

Consumer characteristics

The consumers were female (18) and male (12). The majority (70%) was well distributed among the ages of 22-47. The remaining were 48-55 years of age. They were full-time employees (70%) and students (30%). More than half (60%) of the consumers indicated that they ate out twice a week, 20% seven times a week, and 20% once a week. Most of them (96%) liked (moderately to extremely) to consume fried snack food products such as potato chips, cheese balls, fried peanuts or similar products.

Consumer acceptability

The following interpretation of the 9-point acceptability scale was used for discussion of the cross tabulation percentage results: Like moderately to like extremely was considered the “positive” or “liked” part of the scale, dislike slightly to like slightly was considered

the “neutral” part of the scale, and dislike moderately to dislike extremely was considered the “negative” or “disliked part of the scale. The ECB-C and ECB-G samples were between 6.37 to 7.50 and 6.27 to 7.34 respectively in all attributes (Tables 5).

Appearance liking

Appearance includes sensory attributes such as colour, shape, and size as well as more complex attributes such as surface texture and structural uniformity⁴⁸. Mean scores for acceptability of appearance and colour of ECB (Table 5) showed no influence by the presence of garlic in the formulations. For appearance liking, consumers scored in the range of like moderately to like slightly, which expressed less preference than the other studied sensory attributes. The mean ratings of both the samples were 6.37 (ECB-C) and 6.27 (ECB-G). Appearance liking too had the majority of responses in the positive (liking end) (69% for ECB-C and 64% for ECB-G) (Table 6) but of course rated inferior than flavour, texture or overall acceptability. For both the samples less than 10% of the responses fell in the negative (disliking end) of the scale. An about 1/4th consumers responded appearance of the product was in the neutral centre.

Table 6? Consumer's liking or disliking (%) of the egg crunchy bites after storage six months under ambient conditions (25±2 °C)

Sample	Like Extremely	Like Very Much	Like Moderately	Like Slightly	Neither Like Nor Dislike	Dislike Slightly	Dislike Moderately	Dislike Very Much	Dislike Extremely
Overall acceptability-like or dislike									
ECB-C	7	40	37	10	3	0	3	0	0
ECB-G	3	48	28	7	7	3	3	0	0
Flavour -like or dislike									
ECB-C	7	57	17	7	7	0	3	3	0
ECB-G	10	43	27	7	3	3	3	3	0
Texture (crispiness) -like or dislike									
ECB-C	10	47	33	3	3	0	3	0	0
ECB-G	14	52	17	3	7	0	7	0	0
Appearance -like or dislike									
ECB-C	3	23	43	3	10	7	3	3	3
ECB-G	7	17	40	3	13	10	7	3	0

ECB-C: Egg crunchy bites -Control and ECB-G; Egg crunchy bites with garlic

NOTE: Percentage totals for each question may not result in 100%; results were rounded up or down to the nearest whole number

Flavour Liking

Consumers liked the flavour of both samples as indicated by the mean ratings of 7.2 (ECB-C) and 7.1 (ECB-G) (Table 5). Similar to overall liking results, flavour liking also had the majority of responses in the positive or liking end (81% for ECB-C and 80% for ECB-G) (Table 6). Only 6% samples showed negative response (disliking end) for both the samples. The responses falling in the neutral centre for ECB-C was 14% and for ECB-G was 13% (Table 6).

Texture liking

The mean consumer response for the ECB-C sample was 7.50 and the mean for the ECB-G sample was 7.34 (Table 5). A very high percentage of consumer response (90% ECB-C; 87% for ECB-G) was positive (liking end) (Table 6). In the neutral centre, consumer response for ECB-C and ECB-G samples had only 6% and 10% respectively. Whereas, the responses falling in the negative (disliking end) were minimum (ECB-C, 3% and ECB-G, 7%) compared with flavour and overall acceptability for both the samples.

Overall Liking

For overall liking, consumers liked both samples as indicated by the mean ratings of 7.23 (ECB-C) and 7.10 (ECB-G) (7=like moderately; 8=like very much) (Table 5). Overall liking had more than 75% of responses in the positive (liking end) (84% for ECB-C and 79% for ECB-G (Table 6). For both the samples less than 6% of

the responses fell in the negative (disliking end) of the scale respectively. The responses falling in the neutral centre for ECB-C and ECB-G had 13% and 17% respectively.

Conclusion

A convenience and ready-to-eat snack food from egg was developed. The quality characteristics of the product are reported in this study. The total change in FFA values during storage was found to be the lower in ECB-G than ECB-C. Similarly other oxidative parameters indicated the oxidation was controlled by addition of garlic in the formulation for the production of ECB. Marginal decrease in carotenoid content in ECB-G was observed during storage. Consumers liked both ECB-C and ECB-G as indicated by the mean ratings of 7 and above on 9 point Hedonic scale. Overall liking had more than 75% of responses in the positive end. The product packed in metalized polyester pouch is nutritionally superior and had a shelf life of 6 months under ambient conditions (25±2 °C). The calculated values of amino acids of the samples indicated the presence of essential amino acids thus, making it nutritionally beneficial. The product was found microbiological safe during storage.

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