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Effects of Binders on Physico-chemical Characteristics of Egg Albumen Paneer (EAP)

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ABSTRACT

Background: An innovative food product from egg albumen analogous to the conventional paneer was developed by inclusion of different types of binders and their effects on the physico-chemical qualities of the product were studied.

Methods: Different cereal flours were used as binders *viz.,* juoha rice flour (JRF), glutinous rice flour (GRF), wheat flour (WF) and oat flour (OF) in different ratios, with the egg albumen as the base material for the production of egg albumen paneer (EAP). EAP cubes were packed in food grade high density polyethylene bags and stored at 5-7°C for physico-chemical evaluation upto 90 days. Rehydration properties of the dried products were also studied.

Result: Studies of EAP revealed that pH and water activity differ significant (P<0.01) among the treatments groups and decreased gradually during storage irrespective of the treatment groups and days of storage. The Thiobarbituric acid and Tyrosine values also showed significant (P<0.01) differences among the treatment formulations as well as during the storage days. The rehydration percentage, increase in volume after rehydration and coefficient of rehydration recorded highest in T_1 than the other samples. Both the rehydration ratio and rehydration percentage were recorded highest in T_2 group.

Key words: Binders, Egg albumen, Physico-chemical, Quality, Rehydration.

INTRODUCTION

Eggs are an important source of high quality protein with only some calories and have been recognized as a food of high nutritional value, with the egg albumen concentrating the bulk of egg proteins with almost no fat. The quest for newer and variety of egg products are continuously on rise in the form of number of egg based products *viz.* 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.,* 2003), other than the basics products like boiled eggs, egg in curry, omelette and egg pakoda. Inclusion of the cereal flours in the food formulations may have many health related advantages (Bazzano *et al.*, 2003; Liu *et al.* 2003; Schatzkin *et al.* 2007), while the dietary fibers in cereal flours act as volume enhancer, binder, bulking agent, stabilizer and also improve product's texture (Cofrades *et al.* 2000; Sanchez-Zapata *et al.*, 2010). Oat bran contains higher amount of soluble dietary fibre as compared to wheat flour which contains higher amount of total dietary fiber and insoluble dietary fibre (Talukdar and Sharma, 2010). With this background knowledge, it was planned to develop an egg albumen paneer with different binders as an alternative to traditional milk paneer with added benefits.

MATERIALS AND METHODS

The study was conducted in the Department of Livestock Products Technology, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati in the year 2016.

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Product preparation

Hen eggs were carefully collected from the nearby retail market and checked for quality. Binders and spices were procured from the departmental super market. The formulations were made after a trial study with different percentage of the binders to obtain the desired paneer like shape and texture. Dry binder mix was prepared by mixing the dry ingredients manually in a bowl as per the different formulations like Control (wheat flour-15%, rice flour- 5%), T_1 (glutinous rice flour-10%, joha rice flour-10%), T_2 (glutinous rice flour-8%, oat flour-12%), T_3 (joha rice flour-8%, oat flour-12%) and T_4 (glutinous rice flour-4%, joha rice flour-4% and oat flour-12%). Eggs white was separated from the yolk manually. The batter for egg albumen paneer was prepared by mixing the liquid albumen at 77%, mallic acid, citric acid and spice mix 0.5% each as preservatives and salt 1.5% for taste with the dry binder mix in a mechanical hand blender (Bajaj, India) for 3-5 mins to obtain a homogenous consistency of the batter. It was then poured to a stainless steel mould lined with Aluminium foil and cooked at a temperature range of 80-85°C for 40-45 mins in steam, followed by cooling to ambient temperature. The loaf obtained was then cut into uniform cubes (1 × 1 × 1) inch and vacuum packaged in food grade high density polyethylene bags and stored at 5-7°C temperature for quality studies at regular interval upto 90 days. For studying the rehydration properties of the product, cubes were dried in a hot air oven at 80-85°C for 5-6 hours to get the dehydrated EAP cubes and thereafter evaluated for various parameters.

Physico-chemical properties

Physico-chemical properties of the samples were recorded on the day of production and subsequently on on 5^{th}, 10^{th}, 15^{th}, 20^{th} and upto 90^{th} day for the following parameters.

pH

The pH (Hydrogen Ion Concentration) was determined according to the method of Pippen *et al.* (1965), using a Digital pH Meter (Make: Metrohm, Model: 801 Stirrer).

Thiobarbituric acid (TBA) value

The Thiobarbituric acid (TBA) Value was determined by employing the method as described by Witte *et al.* (1970).

Tyrosine value

Tyrosine value was determined by following the method of Strange *et al.* (1977).

Water activity (a_w)

Water activity (a_w) was determined with the help of a Water Activity Meter (Make: AQUA LAB, Model: 4TE) by taking 10g of dehydrated EAP sample in a sample cup and introduced in to the machine for calculation of the water activity (a_w). The a_w was recorded on the day of production as well as on the subsequent storage days for all the product batches.

Volume increase after rehydration

Rehydration of the cubes was done by soaking the dried cubes in cold water in a beaker for 10 minutes followed by allowing the drainage of the excess water. For 5 dried cubes 20ml of water was used. The per cent increase in volume after rehydration was determined by measuring the volume (length × breadth × height) of rehydrated cubes.

Increase in volume (%) =

$$\frac{\text{Volume after rehydration} - \text{Volume before rehydration}}{\text{Volume before rehydration}} \times 100$$

Coefficient of rehydration

Coefficient of rehydration, rehydration ratio and per cent rehydration in terms of per cent water in rehydrated EAP were calculated as described by Pawar *et al.* (2012).

Coefficient of rehydration =

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

Rehydration ratio

Wt of EAP:Wt. of rehydrated EAP

Per cent water in the rehydrated EAP (Rehydration%)

(Rehydration,%) =

$$\frac{\text{Wt. of rehydrated EAP} - \text{Dry matter content in the sample taken for rehydration*}}{\text{Wt. of rehydrated EAP}} \times 100$$

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

Statistical analysis

Experimental data obtained from the experiment was analyzed following the standard statistical method given by Snedecor and Cochran (1994). Five batches of EAP of each formulation including the control ones were prepared to obtain the data required for statistical analysis. Analysis of variance (ANOVA) with honest significant difference (HSD) test for mean comparison was used to highlight significant differences among the samples. Statistical tests were performed with a 5% or 1% significance level using the SPSS program version 20 (IBM Corp, 2011).

RESULTS AND DISCUSSION

Physico-chemical properties

pH

The pH values differed significantly ($P<0.01$) (Table 1) among the treatment groups and also in the storage days with a slow but gradual decreasing trend irrespective of different formulations and days of storage. The lowest pH values were recorded in the C group as compared to others in all the storage days. However, the interaction between the treatment groups and storage days was non-significant. The relatively higher pH values recorded initially in the treatment groups as compared to the C formulation might be due to the fact that all the treated formulations had high content of rice flours, a very rich source of carbohydrate and also oat flours added in fresh during EAP preparation. But during the storage days these carbohydrate were slowly acted by different lipolytic enzymes (Buege *et al.* 1978) (Saccharolytic/Glycolytic) resulting in the production of different acids, thus lowering the pH values (high acidity) slowly and gradually till the end of storage period. A slightly lower pH value reported by Deepthi *et al.* (2011a) might be related to the difference in varieties of RF and oat flour incorporated in EAP production.

Thiobarbituric acid (TBA) values

The TBA values showed a gradual increasing trend

Table 1: pH of EAP (Mean ± SE).

Treatment \ Days	1	5	10	15	20	25	30	40	50	60	70	80	90
C	$5.896^{A}\pm0.02^{a}$	$5.874^{AB}\pm0.01^{ab}$	$5.836^{BC}\pm0.01^{abc}$	$5.808^{CD}\pm0.01^{bcd}$	$5.772^{DE}\pm0.01^{cde}$	$5.744^{EF}\pm0.02^{def}$	$5.702^{FG}\pm0.02^{ef}$	$5.648^{G}\pm0.02^{fg}$	$5.588^{H}\pm0.01^{gh}$	$5.528^{I}\pm0.02^{hi}$	$5.458^{J}\pm0.02^{ij}$	$5.390^{K}\pm0.01^{jk}$	$5.342^{K}\pm0.01^{k}$
T_1	$6.318^{A}\pm0.06^{a}$	$6.286^{A}\pm0.06^{ab}$	$6.252^{AB}\pm0.06^{abc}$	$6.248^{AB}\pm0.06^{bcd}$	$6.188^{ABC}\pm0.06^{cde}$	$6.150^{ABCD}\pm0.06^{def}$	$6.124^{ABCD}\pm0.06^{ef}$	$6.060^{BCDE}\pm0.06^{fg}$	$6.008^{CDEF}\pm0.06^{gh}$	$5.950^{DEF}\pm0.06^{hi}$	$5.894^{EF}\pm0.07^{ij}$	$5.840^{F}\pm0.07^{j}$	$5.850^{F}\pm0.07^{k}$
T_2	$6.374^{A}\pm0.07^{a}$	$6.342^{A}\pm0.08^{ab}$	$6.316^{AB}\pm0.07^{abc}$	$6.284^{AB}\pm0.07^{bcd}$	$6.258^{ABC}\pm0.07^{cde}$	$6.220^{ABC}\pm0.07^{def}$	$6.182^{ABCD}\pm0.07^{ef}$	$6.126^{ABCDE}\pm0.08^{fg}$	$6.066^{BCDEF}\pm0.08^{gh}$	$6.010^{CDEF}\pm0.08^{hi}$	$5.950^{DEF}\pm0.07^{ij}$	$5.904^{EF}\pm0.08^{jk}$	$5.850^{F}\pm0.07^{k}$
T_3	$6.558^{A}\pm0.08^{a}$	$6.516^{A}\pm0.08^{ab}$	$6.490^{AB}\pm0.08^{abc}$	$6.438^{ABC}\pm0.08^{bcd}$	$6.422^{ABC}\pm0.07^{cde}$	$6.352^{ABCD}\pm0.06^{def}$	$6.326^{ABCD}\pm0.06^{ef}$	$6.266^{BCDE}\pm0.06^{fg}$	$6.202^{CDEF}\pm0.06^{gh}$	$6.142^{DEFG}\pm0.06^{hi}$	$6.074^{EFG}\pm0.07^{ij}$	$6.020^{FG}\pm0.07^{jk}$	$5.966^{G}\pm0.07^{k}$
T_4	$6.352^{A}\pm0.08^{a}$	$6.318^{A}\pm0.07^{ab}$	$6.290^{AB}\pm0.08^{abc}$	$6.250^{ABC}\pm0.07^{bcd}$	$6.210^{ABC}\pm0.08^{cde}$	$6.178^{ABCD}\pm0.08^{def}$	$6.148^{ABCD}\pm0.09^{ef}$	$6.100^{ABCDE}\pm0.08^{fg}$	$6.036^{BCDEF}\pm0.08^{gh}$	$5.984^{CDEF}\pm0.08^{hi}$	$5.934^{DEF}\pm0.08^{ij}$	$5.874^{EF}\pm0.07^{jk}$	$5.818^{F}\pm0.07^{k}$

Mean with superscript bearing similar alphabet (capital and small) do not differ significantly.
Mean with superscript bearing different alphabet (capital and small) differ significantly.

irrespective of treatment groups and days of storage, however itwas within the permissible limit of 2 mg malonaldehyde/kg of food product. On day-1, the highest TBARS value was recorded in T_4 while it was lowest in T_1 group (Table 2). However, on 90th day the highest TBARS value was recorded in C and the lowest in T_2 formulation. The gradual increase in TBARS values of EAP might be related to the lipid oxidation caused by different lipolytic enzymes (Buege *et al*. 1978) present in EAP for which there were gradual increase in malonaldehyde values during the storage days. Moreover, albumen has high foaming property that entraps oxygen within it and this might have also contributed in oxidation of lipid Deepthi *et al.* (2011a). Considering the fact that the lipid content of egg albumen is very less *i.e.*,1.09% (Bashir *et al.*2015) as compared to the flours incorporated in EAP and this could be the possible reasons for very slow but gradual rise in TBARS values during the storage days. The TBARS values recorded for C formulation in the study was nearer to the ones reported by Deepthi *et al.* (2011a) who also reported TBARS values that varies from 0.66±0.04 to 1.24±0.07 in EAP during the storage period of 6 months. Several other investigators also reported an increase in TBARS values along with the increase in storage period although most of them had worked on certain meat products (Jebin 2011; Sebranek *et al.* 2005).

Tyrosine value

Tyrosine values of EAP increased gradually irrespective of the treatment groups and days of storage. The lowest Tyrosine values were recorded on day-1, having lowest value in T_3 and highest in C formulation (Table 3). A very similar trend was also observed on 90th day of storage with highest value in C and lowest in T_3 formulations. The gradual increase in Tyrosine values of EAP might be related to the continuous protein denaturation by the different proteolytic enzymes *i.e.* Proteases/Cathepsins and others present in EAP. Moreover, egg albumen is very rich in protein content *i.e.*, 3.48% (Bashir *et al.* 2015) which might have facilitated the proteolysis process during the storage days resulting in a gradual rise of tyrosine values of EAP. Several other workers also reported increase in Tyrosine values of their meat food products during the storage period (Mahmmod *et al.* 2014).

Water activity (a_w)

Water activity (a_w) of EAP revealed a gradual decrease in values irrespective of treatment groups and the days of storage and varies between 0.5795±0.005 to 0.7357±0.004 during storage (Table 4). On day-1, the T_3 formulation recorded highest and T_1 formulation recorded lowest a_w. However, on 90th day of storage, the T_3 and C formulation registered highest and lowest a_w values respectively. The gradual fall in a_w values of EAP might be a corollary to the continuous drop in pH values during the storage days and vacuum packaging of EAPs with high density polyethylene (HDPE) packaging material. This gradual fall in a_w values of EAP during their storage time might have resulted in the

Table 2: TBARS values (mg malonaldehyde/kg) of EAP (Mean±SE).

Treatments \ Days	Days of storage												
	1	5	10	15	20	25	30	40	50	60	70	80	90
C	0.678±^{AB}	0.709±^{A}	0.736±^{A}	0.778±^{A}	0.808±^{A}	0.842±^{A}	0.874±^{A}	0.930±^{A}	0.972±^{A}	1.017±^{A}	1.065±^{A}	1.124±^{A}	1.166±^{A}
	$_{j}$0.012	$_{ji}$0.016	$_{ji}$0.017	$_{ih}$0.024	$_{hg}$0.025	$_{hg}$0.028	$_{gf}$0.028	$_{fe}$0.026	$_{ed}$0.024	$_{dc}$0.023	$_{cb}$0.0221	$_{ba}$0.022	$_{a}$0.028
T_1	0.640±^{B}	0.667±^{A}	0.694±^{A}	0.736±^{A}	0.767±^{AB}	0.801±^{AB}	0.842±^{A}	0.886±^{AB}	0.944±^{A}	0.998±^{AB}	1.041±^{A}	$_{b}$0.017	$_{a}$0.014
	$_{j}$0.019	$_{j}$0.019	$_{ji}$0.019	$_{ih}$0.024	$_{hg}$0.018	$_{gf}$0.017	$_{fe}$0.016	$_{e}$0.014	$_{d}$0.017	$_{c}$0.017	$_{c}$0.014	1.096±^{AB}	1.157±^{A}
T_2	0.641±^{B}	0.666±^{A}	0.691±^{A}	0.722±^{A}	0.747±^{B}	0.775±^{B}	0.811±^{A}	0.855±^{B}	0.885±^{B}	0.943±^{B}	1.004±^{A}	$_{ba}$0.018	1.105±^{A}
	$_{j}$0.014	$_{ji}$0.018	$_{jih}$0.018	$_{ihg}$0.018	$_{hg}$0.019	$_{gf}$0.019	$_{fe}$0.021	$_{ed}$0.022	$_{dc}$0.019	$_{c}$0.026	$_{b}$0.028	1.05±^{B}	$_{a}$0.021
T_3	0.665±^{AB}	0.691±^{A}	0.718±^{A}	0.743±^{A}	0.775±^{AB}	0.805±^{AB}	0.837±^{A}	0.882±^{AB}	0.933±^{AB}	0.982±^{AB}	1.030±^{A}	$_{b}$0.016	$_{a}$0.022
	$_{k}$0.015	$_{kj}$0.014	$_{kj}$0.017	$_{ji}$0.019	$_{ih}$0.017	$_{hg}$0.021	$_{gf}$0.020	$_{fe}$0.021	$_{ed}$0.018	$_{dc}$0.017	$_{c}$0.016	1.089±^{AB}	1.145±^{A}
T_4	0.693±^{A}	0.714±^{A}	0.740±^{A}	0.767±^{A}	0.805±^{AB}	0.831±^{AB}	0.863±^{A}	0.907±^{AB}	0.956±^{A}	1.005±^{AB}	1.047±^{A}	$_{b}$0.018	$_{a}$0.018
	$_{k}$0.008	$_{kj}$0.007	$_{ji}$0.006	$_{i}$0.003	$_{h}$0.004	$_{hg}$0.003	$_{g}$0.007	$_{f}$0.008	$_{e}$0.012	$_{d}$0.016	$_{c}$0.017	1.093±^{AB}	1.154±^{A}

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Table 3: Tyrosine values of EAP(Mean ± SE)

Treatments \ Days	Days of storage												
	1	5	10	15	20	25	30	40	50	60	70	80	90
C	13.805^{A}	14.740^{A}	15.900^{A}	17.010^{A}	18.035^{A}	18.940^{A}	20.220^{A}	21.580^{A}	23.335^{A}	24.950^{A}	27.075^{A}	28.365^{A}	29.810^{A}
	$_{j}$±0.317	$_{j}$±0.495	$_{ji}$±0.480	$_{ih}$±0.532	$_{ihg}$±0.653	$_{hg}$±0.678	$_{gf}$±0.642	$_{fe}$±0.765	$_{ed}$±1.109	$_{dc}$±0.992	$_{cb}$±0.800	$_{ba}$±0.882	$_{a}$±1.043
T_1	10.360^{C}	10.980^{C}	11.905^{C}	12.625^{C}	13.825^{C}	14.890^{C}	15.820^{C}	18.255^{BC}	19.705^{B}	21.175^{B}	22.745^{B}	24.194^{B}	26.115^{B}
	$_{h}$±0.208	$_{h}$±0.304	$_{hg}$±0.362	$_{hg}$±0.400	$_{gf}$±0.481	$_{f}$±0.554	$_{f}$±0.580	$_{e}$±0.654	$_{ed}$±0.713	$_{dc}$±0.019	$_{cb}$±1.129	$_{ba}$±1.125	$_{a}$±1.150
T_2	12.155^{B}	12.910^{B}	14.040^{B}	14.695^{B}	15.770^{B}	16.705^{B}	17.610^{B}	19.145^{B}	20.755^{AB}	22.410^{B}	24.160^{B}	26.125^{AB}	27.685^{AB}
	$_{k}$±0.269	$_{kj}$±0.333	$_{ji}$±0.354	$_{ih}$±0.321	$_{hg}$±0.429	$_{gf}$±0.482	$_{fe}$±0.682	$_{ed}$±0.706	$_{d}$±0.703	$_{c}$±0.736	$_{b}$±0.764	$_{a}$±0.723	$_{a}$±0.608
T_3	8.205^{E}	9.350^{D}	10.480^{D}	11.615^{C}	12.595^{C}	13.855^{C}	14.935^{C}	16.805^{C}	17.725^{B}	20.380^{B}	22.040^{B}	24.240^{B}	25.505^{B}
	$_{i}$±0.322	$_{ih}$±0.456	$_{hg}$±0.420	$_{g}$±0.499	$_{gf}$±0.680	$_{fe}$±0.694	$_{ed}$±0.681	$_{dc}$±0.720	$_{c}$±0.416	$_{b}$±0.694	$_{b}$±0.738	$_{a}$±0.836	$_{a}$±0.652
T_4	9.455^{D}	10.235^{CD}	11.020^{CD}	11.830^{C}	13.135^{C}	14.305^{C}	15.655^{C}	16.965^{C}	18.460^{B}	20.515^{B}	22.405^{B}	24.440^{B}	26.310^{B}
	$_{k}$±0.321	$_{kj}$±0.296	$_{kj}$±0.219	$_{ji}$±0.266	$_{ih}$±0.313	$_{hg}$±0.389	$_{gf}$±0.397	$_{fe}$±0.405	$_{e}$±0.625	$_{d}$±0.665	$_{c}$±0.859	$_{b}$±0.994	$_{a}$±0.964

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Table 4: Water activity of EAP (Mean±SE).

Treatments \ Days	Days of Storage									
	1	10	20	30	40	50	60	70	80	90
C	0.6950^{D} ±0.005$_{a}$	0.6940^{D} ±0.005$_{ab}$	0.6922^{D} ±0.005$_{abc}$	0.6909^{D} ±0.005$_{abc}$	0.6902^{D} ±0.004$_{abc}$	0.6891^{D} ±0.005$_{abc}$	0.6866^{D} ±0.006$_{abc}$	0.6855^{D} ±0.006$_{abc}$	0.6847^{D} ±0.006$_{bc}$	0.6840^{D} ±0.006$_{c}$
T_1	0.5795^{E} ±0.005$_{a}$	0.5783^{E} ±0.004$_{ab}$	0.5770^{E} ±0.004$_{abc}$	0.5759^{E} ±0.003$_{abc}$	0.5745^{E} ±0.003$_{abc}$	0.5737^{E} ±0.003$_{abc}$	0.5730^{E} ±0.002$_{abc}$	0.5720^{E} ±0.002$_{abc}$	0.5710^{E} ±0.002$_{bc}$	0.5702^{E} ±0.002$_{c}$
T_2	0.7298^{B} ±0.004$_{a}$	0.7291^{B} ±0.004$_{ab}$	0.7284^{B} ±0.003$_{abc}$	0.7275^{B} ±0.003$_{abc}$	0.7267^{B} ±0.003$_{abc}$	0.7262^{B} ±0.003$_{abc}$	0.7256^{B} ±0.003$_{abc}$	0.7248^{B} ±0.003$_{abc}$	0.7239^{B} ±0.003$_{bc}$	0.7232^{B} ±0.003$_{c}$
T_3	0.7401^{A} ±0.005$_{a}$	0.7393^{A} ±0.005$_{ab}$	0.7387^{A} ±0.005$_{abc}$	0.7386^{A} ±0.005$_{abc}$	0.7379^{A} ±0.005$_{abc}$	0.7379^{A} ±0.005$_{abc}$	0.7373^{A} ±0.005$_{abc}$	0.7371^{A} ±0.004$_{abc}$	0.7364^{A} ±0.004$_{bc}$	0.7357^{A} ±0.004$_{c}$
T_4	0.7058^{C} ±0.003$_{a}$	0.7051^{C} ±0.003$_{ab}$	0.7044^{C} ±0.003$_{abc}$	0.7037^{C} ±0.003$_{abc}$	0.7031^{C} ±0.003$_{abc}$	0.7025^{C} ±0.003$_{abc}$	0.7019^{C} ±0.003$_{abc}$	0.7013^{C} ±0.003$_{abc}$	0.7005^{C} ±0.003$_{bc}$	0.6997^{C} ±0.003$_{c}$

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absence of microbial count as observed in the present study. The a_w values recorded for the C formulation were at variance with the ones reported by Deepthi *et al.* (2011a) for EAPs prepared with same incorporation levels of WF and RFs. This discrepancy could be attributed to the vacuum packaging of EAP with HDPE packaging material, besides, storing of the product (EAP) at refrigeration temperature (5 -7°C).

Increase in volume on rehydration

The increase in volume on rehydration values of EAP ranges between 120.69±1.57 to 153.07±7.00. There was no significant differences in increase in volume on rehydration among the T_3 and T_4 groups whereas the other formulations recorded a significant difference (P<0.05) (Table 5). The highest increase in volume on rehydration value recorded in T_1 formulation might be due to incorporation of only rice flours (10% GRF and 10% JRF) in EAP preparation since rice flours has higher water binding capacity as compared to wheat and oat flours. The lowest increase in volume value recorded in the control group might be a reflection of incorporation of high percentages of wheat flour (15%) which has poor water absorption capacity. The results obtained in the study for increase in volume on rehydration were in contrast to that of Deepthi *et al.* (2011b). The higher increase in volume on rehydration values recorded in the present studies might be due to the differences in the product formulation, *i.e.* incorporation of GRF and JRF, besides oat flour.

Coefficient of rehydration

No significant differences in coefficient of rehydration were found among the T_1, T_2, T_3 and T_4 groups, however, the control group showed a significant difference (P<0.05) (Table 5) with the other formulations. The highest coefficient of rehydration recorded in T_1 formulation might be due to incorporation of only rice flours having higher water binding capacity. A much lower coefficient of rehydration registered in the control group might be due to the same explanation as has been given for rehydration of EAP. Lower coefficient of rehydration value as reported by Deepthi *et al.* (2011a) might be due to their evaluation of EAP at monthly intervals and also on storage of the product at 27±2°C which was much higher than the one followed in the present study *i.e.* 5-7°C.

Rehydration ratio

There was no significant differences in rehydration ratios among the control and T_4 groups whereas, the T_1, T_2, T_3 groups recorded a significant difference (P<0.05) (Table 5) with the other formulations. The highest rehydration ratio recorded in T_2 formulation might be a reflection of much higher fiber content in oat flour (3.53-5.87% fiber, Youssef *et al.,* 2016) that was added at 12% along with 8% level GRF (0.9%, Itthivadhanapong and Sangnark, 2016). The study further revealed almost equal rehydration ratio of EAP in Control and T_4 formulations. This could be attributed to

Table 5: Increase in volume on rehydration, co-efficient of rehydration, rehydration ratio and rehydration percentage values of EAP (Mean±SE).

Treatments groups	Increase in volume after rehydration %	Coefficient of rehydration	Rehydration ratio	Rehydration %
C	120.69 ± 1.57^{C}	3.21 ± 0.24^{B}	2.17 ± 0.07^{B}	87.06 ± 2.31^{C}
T_1	153.07 ± 7.00^{A}	4.96 ± 0.33^{A}	2.41 ± 0.09^{AB}	93.26 ± 1.15^{BC}
T_2	146.31 ± 4.25^{AB}	4.51 ± 0.17^{A}	2.55 ± 0.09^{A}	104.92 ± 5.38^{A}
T_3	136.80 ± 5.00^{B}	4.81 ± 0.29^{A}	2.40 ± 0.07^{AB}	99.89 ± 2.52^{AB}
T_4	135.97±5.94B	4.75±0.30A	2.16±0.13B	103.40±3.60AB

Mean with superscript bearing similar alphabet (capital) do not differ significantly.
Mean with superscript bearing different alphabet (capital) differ significantly.

much lower fiber content in JRF (0.25-0.75%, Roy *et al.*, 2010) and slightly higher fiber content in oat and wheat flours incorporated in T_4 and Control formulations of EAP.

Rehydration percentage

The rehydration percentage of different formulations of EAP varies between 87.06±2.31 to 104.92±5.38 per cent. No significant differences in rehydration percentages were observed between the T_3 and T_4 groups. On the contrary, the C, T_1 and T_2 groups revealed significant differences ($P<0.05$) (Table 5) with the other two formulations. The highest rehydration percentage recorded in T_2 formulation might again be a reflection of high fiber content in GRF while the lowest in control group might be ascribed to incorporation of 15% wheat flour (low in fiber content) and only 5% rice flour (RF).

The results for Rehydration percentage recorded in the study for the control group was almost in conformity with the findings of Deepthi *et al.* (2011a) who also recorded (84.10±5.35) rehydration percentage on '0' day of storage of EAP prepared by incorporation of same levels of WF and RF as followed in the control formulation of EAP in the present study.

CONCLUSION

An ease and ready-to-use product was prepared from egg albumen by incorporating GRF, JRF and Oat flour other than WF and RF. The physico-chemical characteristics of the product obtained in the study were reported. Treatments groups have a better quality aspects in terms of pH, TBA, Tyrosine value and water activity, than the control samples. Rehydration properties were also found to be better for the treatment groups than the control ones, with special mentioning of the T_1 and T_2 groups. The product alike to the traditional milk based paneer and has a better acceptability in terms of its physico-chemical properties and can be used in our day to day diet in the form of curry, snacks, *etc.*

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