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Effect of vegetables gums on proximate, functional, optical and sensory attributes of catfish nuggets during chilled storage

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ABSTRACT

The present work was aimed to investigate the possibility of incorporating vegetable gums as binders in nuggets prepared from freshwater catfish, *Pangasius pangasius*. Guar gum and gum Acacia, which are well-known texturising agents were added in varying quantities during the preparation of the nuggets. Proximate analysis indicated that moisture content decreased from 78.9 to 74.0%, with increasing concentration of gum (0 – 2%), and so did fat content, from 6.1 to 5.4%. Protein content went up from 15.5% in control to 19.3% in treated sample. Control sample underwent maximum cooking loss (≈3.5%), whereas both treatments T4 (2% guar gum, *w/w*) and T7 (2% gum Acacia, *w/w*), exhibited minimum loss (≈ 2.7%). CIE L*a*b* values indicated significant lightening of the product during prolonged storage at 0 ^{0}C). Textural and sensory evaluation data also indicated that vegetable gums could be incorporated successfully in fish nuggets to improve their texture and sensory attributes. In all the treated and stored samples (0 ^{0}C, 60 days), the presence of bacteria, yeast and mould were well within permissible limits (≤ 3.0×10^2 cfu/g and ≤ 2.8×10^1 cfu/g, respectively).

Key words: Binder, Fish nuggets, Gum Acacia; Guar gum, *Pangasius*, Texturising agent.

INTRODUCTION

Nuggets are convenience foods, prepared from mince of meat or fish fillets (Balachandran, 2001). These re-structured, value-added products often involve utilization of surplus perishable stocks, thereby increasing profitability of fish / meat processing units. Various binders are used in nuggets, ranging from eggs, corn starch, various flours, milk solids, as well as purées obtained from pumpkin and sweet potato. Binders also affect the textural properties of the foodstuff. In the present work, Guar and Acacia gums were evaluated as binding agents in nuggets prepared from mince of catfish *Pangasius pangasius*, colloquially called *basa*, *bacha* or *bachua*. This fish variety, originally from South East Asia, is now being systematically cultivated in India, due to its fast growing nature, indiscriminate eating habits and ability to survive in open aquaculture ponds and fish cages. Due to unregulated production and haphazard growth, the supply of this fish can be erratic, resulting in price fluctuations and market glut. It has also been reported that Indian consumers may prefer *Pangasius* fish imported from Vietnam, to the ones raised indigenously, due to the latter's poor quality and the "unhealthy" race used by growers for attaining higher yield, in violation of the National Fisheries Development Board (NFBD) guidelines (Anonymous 2011). Since fish are a highly perishable commodity, distress selling can be avoided, and fish farmers can be insulated from uncertain markets to a large extent, if options for value-added products exist.

Recently, the organoleptic evaluation of nuggets prepared from *Pangasius*, using various binding and texturising agents including tapioca flour, cornstarch, flour and egg white was reported (Rario, 2015). It was concluded that nuggets with 30% wheat flour content had highest consumer preference. Natural gums, which are basically hydrocolloids, are well-known binding and texturising agents (Panda, 2010). Literature survey revealed that considerable amount of work has been done on use of natural gums as battering and coating agents for food products, including fish fillets (Foegeding and Ramsey, 1987; Shabanpour, 2013). Both gum Acacia and Guar gum, contain galacto-pyranose moieties as structural units. Guar gum has been reported to be an important source of soluble dietary fibre (Yoon *et al*, 2008). Similarly, recent research (Ali *et al*, 2009) on gum Acacia also indicates that its ingestion may reduce plasma cholesterol concentration, together with other benefits, including dental re-mineralisation. In the present work, Guar gum and gum Acacia were evaluated for their possible use as binding agents, enhancing functional properties (typically reduction in moisture content and oil uptake), storage characteristics, as well as consumer preference of fish nuggets through ranking test as per Hedonic Scale.

MATERIALS AND METHODS

Fresh catfish (*P. pangasius*), was procured from the local wholesale market. Laboratory grade gum Acacia and

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Guar gum were obtained from M/s Himedia, Mumbai. A dry spice mix comprising of equal proportion of black pepper, clove, cinnamon, and fennel (3% *w/w*), green spices mix (green chillies, coriander and mint leaves) and seasoning were used for preparing the nuggets; rice bran oil was selected as frying medium. Different gums were incorporated in the nuggets as per Table 1.

Preparation of nuggets: The various steps involved in the preparation of nuggets included cleaning and deboning of fresh fish, washing with cold water (5 ^{o}C), filleting and draining out the excess water by applying manual pressure. The fillets were then ground to fine paste, followed by addition of vegetable gum (1, 1.5 and 2%, *w/w*), along with spices. The mixture was then transferred to square-shaped aluminum molding trays greased with oil and steamed for 30 mins. The excess water that came out as exudate while steaming was drained out. The steamed paste was cut into uniform cubes of 1.5 cm^3 dimension. The samples were then stored in LDPE pouches at 0 ^{0}C (Sanco refrigerated cabinet, equipped with Thermotech digital temperature controller) and evaluated on 0, 15, 30 and 60 days of storage. The steamed nuggets were evaluated for initial cooking loss and changes in microbiological profile on storage. The nuggets were subsequently fried in rice bran oil for 6 minutes at 160 ^{o}C, using an electric deep fat fryer (Severin 2408, Germany) and subjected to proximate analysis, color profile, texture profile analysis and sensory evaluation.

Proximate analysis: The proximate composition (dry matter, moisture, fat, and protein), of the fried nuggets were determined as per standard procedure (AOAC, 2005).

Cooking loss: The weight of fish nuggets lost during steaming was calculated by the general formula:

Table 1: Different treatments prepared by incorporating gums / kg in catfish nugget mix

Treatment	Gum	%
T1(Control)	NIL	Nil
T2	Guar Gum	1
T3	-do-	1.5
T4	-do-	2
T5	Gum Acacia	1
T6	-do-	1.5
T7	-do-	2

$$\text{Cooking loss (\%)} = \frac{\text{Wt. of pre-cooked nuggets} - \text{Wt. of post-cooked nuggets}}{\text{Wt. of pre-cooked nugget}} \times 100$$

Microbiological analysis: Total aerobic plate count (TPC) and Total mould count of steamed fish nuggets were enumerated as per FSSAI Guidelines (2012), spread over a period of 60 days, at 15 day intervals.

Color analysis: CIE L*a*b* values (Lightness L*, Redness a* and Yellowness b*) of the fried fish nugget samples were examined with a HunterLab Scan XE spectrophotometer, which was standardized with a white color standard (CIE, 2008).

Textural characteristics: Texture profile analysis (TPA) of the fried fish nuggets was determined by a TA.XT plus Stable Microsystem texture analyzer, coupled with HDP/90 platform and Exponent Lite version: 5.1.1.0 software. The samples were evaluated for hardness, chewiness, gumminess, cohesiveness, springiness and resilience. All the fried samples were cooled to room temperature prior to the textural determination. Texture profile analysis was performed using central cores of three pieces of each sample (1.5 cm^3), which were compressed twice to 80% of the original height by a compression probe (P 35). A cross-head speed of 5 mm/s was used for the tests.

Sensory evaluation: The fried nuggets were evaluated for their color, flavor, taste, texture, stickiness, appearance and overall acceptability by a taste panel of 10 members picked from a pool of select panelists, using a 9-point Hedonic scale, where 9 represents the highest score.

Statistical analysis: All experiments were conducted in triplicate. Data obtained from the analyses were analyzed by using Single Factor Analysis of Variance (ANOVA). Statistical significance was indicated at 95% confidence level.

RESULTS AND DISCUSSION

Proximate composition of control and treated nuggets: As shown in Table 2, the proximate composition of fish nuggets was significantly different ($p < 0.05$). The untreated fish nuggets (T1) had a moisture content of 78.9%, which was higher as compared to the samples containing gums; this ranged from 74.0 - 76.9%. Fish nuggets containing 2% gum Acacia (T7) had the lowest (p <0.05) moisture content

Table 2: Proximate composition of catfish nuggets

Treatment	Dry matter (%)	Moisture (%)	Protein (%)	Fat (%)
T1(Control)	21.2	78.9 ± 0.1	15.5 ± 0.1	6.1 ± 0.1
T2	22.2	76.9 ± 0.001	16.8 ± 0.2	5.8 ± 0.01
T3	23.5	76.5 ± 0.1	18.9 ± 0.1	5.6 ± 0.01
T4	24.9	75.1 ± 0.2	19.3 ± 0.01	5.4 ± 0.01
T5	21.6	76.3 ± 0.01	16.5 ± 0.1	5.8 ± 0.1
T6	23.2	74.8 ± 0.01	18.5 ± 0.01	5.7 ± 0.01
T7	24.5	74.0 ± 0.01	18.9 ± 0.01	5.6 ± 0.02

(74.0%). Generally higher moisture content is expected when hydrocolloids such as food gums are added as ingredient. However, the moisture content of treated samples decreased with increase in the concentration of gums. The lower moisture content observed in the present study may be related to the lower proportion of fish meat in the formulation. The protein value of the samples ranged from 15.5 to 19.3%. Treatment T4 obtained by addition of 2% Guar gum had the highest (p <0.05) protein content (19.3%). The protein content increased with increasing concentration of gums, which may be attributed to the protein present in Guar gum (Sabahelkheir *et al*, 2012), as well as gum Acacia (Osman ME, 1993).

Use of various hydrocolloids in reducing the oil uptake of deep fried, high protein foods has showed that the addition of hydrocolloids significantly reduced oil uptake during frying (Bajaj *et al*, 2007). This is attributed to the thermal gelation of these hydrocolloids at frying temperatures, which creates an oil-resistant gum-protein matrix in the fried article, thereby lowering the oil absorption (Ang *et al*, 1991). In the present work, the fat content of the fried fish nuggets varied from 5.4 to 6.1%. The sample with 2% Guar gum (T4) had the lowest (p <0.05) fat content. The higher the concentration of gum, the lower was the observed fat content of the fried nuggets. Previously Gennadios *et al*. (1997) had showed a decrease in the oil absorption of gum coated chicken fillets during deep fat frying. Oil uptake during frying is a surface phenomenon. An increased hydrophobic character of the surface would result in increased oil uptake during frying (Pinthus and Saguy, 1994). The ability of Guar and Acacia gums to reduce oil uptake in fish nuggets could be attributed to the predominant hydrophilic character of these gums. Moreover, moisture content on the surface layers of the product has a major impact on oil uptake during deep fat frying. This is because, during deep frying moisture escapes for the surface at a faster rate leaving a negative pressure in the hollow lattices, through which oil can easily enter into the hydrophobic protein matrix. In treated samples, water molecules are strongly held by the hydrophilic gum molecules in a three-dimensional network of protein-gum gel, thereby preventing the diffusion of oil into the matrix.

Cooking loss: Calculation of cooking loss (Fig 1) clearly indicated that T1 (control) underwent maximum loss to the tune of ≈3.5%. On the other hand, treatments T4 and T7 exhibited minimum loss of ≈2.7% which corresponds to the highest concentrations of Guar gum and Gum Acacia, respectively. This may be related to the higher water-holding capacity (WHC) of hydrocolloid gums, as they reduce the availability of free water in the product. The WHC indicates a protein's ability to bind water and is generally used to objectively evaluate the quality and yield of meat products (Sun *et al*, 2011). The colloidal nature and polymeric molecular structure of gums contribute to their higher water-holding capacities. Upon heating in the presence of sufficient water molecules, these polymeric chains undergo structural rearrangements and entrap water within the newly formed three dimensional gel structures of muscle proteins. As gums contain a higher amount of charged residues such as hydroxyl (-OH) groups, contribution of the gums to gel water binding via electrostatic interactions and the hydrogen bonds would also be possible. These results are in a good agreement with the findings for other protein-polysaccharide composite gels (Foegeding *et al*, 1987)

Microbiological analysis of nuggets during storage: Currently, microbiological standards for foods in India are covered under Appendix B of Food Safety and Standards (Food Products Standards and Food Additives) Regulation (FSSAI, 2012). On November 13, 2015, India's food

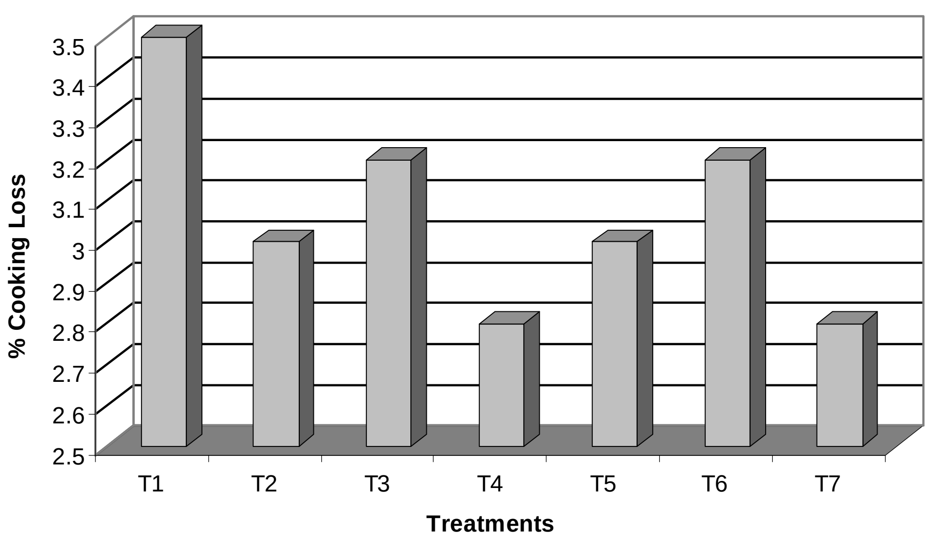

Fig 1: Cooking loss in catfish nuggets

regulator, FSSAI, proposed new microbiological standards for fish and fish products, in which a minimum of 5 x 10^3 cfu/g and a maximum of 5 x 10^4 cfu/g aerobic plate count was mooted for convenience fishery products. It did not specify similar standards for yeast and mould count. In the present work, microbiological analysis of the processed product, including total plate count and total mold count were recorded up to 60 days of storage. It was observed that the aerobic mesophilic total plate count ranged from 2.7 – 30.0 x 10^2 after 60 days of storage period; total mold count ranged from 2.4 – 2.7 x 10^1 cfu/g. The data amply revealed that the presence of bacteria, yeast and moulds in the samples were well within permissible limits even after prolonged storage period of 60 days, at 0 ^{0}C (Table 3). There was only marginal difference between treated and untreated samples during storage, indicating the negligible effect of gum addition on common microflora of the fish nuggets.

Optical properties of nuggets during storage : Lightness L*, redness a* and yellowness b* did not differ significantly (*p* >0.05) amongst the treatments indicating that the changes in the formulations did not affect color parameters of freshly prepared fish nugget (Table 4). However, there was significant difference (*p* <0.05) in the L*, a* and b* values of both treated and untreated samples during extended period of low temperature storage. Fish nuggets with 2% gum Acacia (T7) showed the highest L*a*b* values with

Table 3: Total Plate Count and Total Mould Count of catfish nuggets at various storage periods

Treatments	TPC (0 Day) cfu/g	TPC (15 Day) cfu/g	TPC (30 Day) cfu/g	TPC (60 Day) cfu/g	TMC (0 Day) cfu/g	TMC (15 Day) cfu/g	TMC (30 Day) cfu/g	TMC (60 Day) cfu/g
T1 (Control)	2.4×10^{2}	2.8×10^{2}	2.9×10^{2}	3.0×10^{2}	1×10^{1}	2.1×10^{1}	2.3×10^{1}	2.8×10^{1}
T2	2.3×10^{2}	2.5×10^{2}	2.6×10^{2}	2.8×10^{2}	1×10^{1}	2.0×10^{1}	2.2×10^{1}	2.4×10^{1}
T3	2.2×10^{2}	2.4×10^{2}	2.5×10^{2}	2.7×10^{2}	1×10^{1}	2.3×10^{1}	2.4×10^{1}	2.5×10^{1}
T4	2.3×10^{2}	2.5×10^{2}	2.6×10^{2}	2.8×10^{2}	1×10^{1}	2.2×10^{1}	2.5×10^{1}	2.3×10^{1}
T5	2.4×10^{2}	2.6×10^{2}	2.7×10^{2}	2.8×10^{2}	1×10^{1}	2.4×10^{1}	2.5×10^{1}	2.6×10^{1}
T6	2.4×10^{2}	2.7×10^{2}	2.8×10^{2}	2.9×10^{2}	1×10^{1}	2.3×10^{1}	2.5×10^{1}	2.6×10^{1}
T7	2.5×10^{2}	2.6×10^{2}	2.7×10^{2}	2.8×10^{2}	1×10^{1}	2.4×10^{1}	2.6×10^{1}	2.7×10^{1}

Table 4: Color analysis of fish nuggets indicating changes in L* a* b* values at various storage periods

ATTRIBUTES	TREATMENT	STORAGE PERIOD			
		0 DAY	15 DAYS	30 DAYS	60 DAYS
LIGHTNESS (L)	T1 (control)	30.07 ± 0.09	24.90 ± 0.6	24.66 ± 0.4	22.13 ± 0.02
	T2	29.12 ± 0.4	23.11 ± 0.9	29.76 ± 0.1	23.17 ± 0.1
	T3	28.32 ± 0.6	25.97 ± 0.4	27.66 ± 0.1	20.87 ± 0.1
	T4	30.68 ± 0.4	25.12 ± 0.4	31.65 ± 0.9	19.16 ± 0.1
	T5	30.13 ± 0.7	25.35 ± 0.6	28.26 ± 0.7	21.15 ± 0.1
	T6	27.58 ± 0.3	23.38 ± 0.7	31.41 ± 0.5	25.27 ± 0.1
	T7	31.12 ± 0.6	27.19 ± 0.5	32.43 ± 0.7	28.32 ± 0.1
REDNESS (a)	T1 (control)	6.02 ± 0.3	6.24 ± 0.3	4.35 ± 0.2	-2.27 ± 0.6
	T2	6.36 ± 0.2	4.90 ± 0.4	4.67 ± 0.1	3.54 ± 0.1
	T3	5.58 ± 0.4	5.36 ± 0.7	5.03 ± 0.1	3.49 ± 0.01
	T4	6.17 ± 0.2	5.03 ± 0.6	5.64 ± 0.0	2.43 ± 0.02
	T5	5.59 ± 0.1	5.63 ± 0.4	4.85 ± 0.1	2.79 ± 0.1
	T6	5.35 ± 0.1	4.69 ± 0.8	4.60 ± 0.4	2.88 ± 0.1
	T7	6.02 ± 0.2	6.41 ± 0.0	5.53 ± 0.1	3.63 ± 0.1
YELLOWNESS (b)	T1 (control)	12.70 ± 0.8	10.34 ± 0.4	9.18 ± 0.5	-7.55 ± 0.06
	T2	11.73 ± 0.9	8.47 ± 0.4	11.40 ± 0.3	9.50 ± 0.1
	T3	11.85 ± 0.7	10.58 ± 0.5	10.54 ± 0.1	8.66 ± 0.1
	T4	13.02 ± 0.2	9.08 ± 0.5	12.50 ± 0.3	6.93 ± 0.1
	T5	11.78 ± 0.2	10.20 ± 0.7	10.57 ± 0.3	7.95 ± 0.1
	T6	11.14 ± 0.1	9.75 ± 0.4	11.76 ± 0.1	9.90 ± 0.1
	T7	13.18 ± 0.2	12.26 ± 0.4	11.50 ± 0.3	11.19 ± 0.1
COLOUR DIFFERENCE (?E)	T1 (control)	0.92 ± 0.01	3.62 ± 0.3	6.68 ± 0.1	5.11 ± 0.1
	T2	1.49 ± 0.1	8.77 ± 0.2	8.15 ± 0.01	8.15 ± 0.01
	T3	2.14 ± 0.2	5.38 ± 0.3	10.47 ± 0.01	10.47 ± 0.01
	T4	1.77 ± 0.09	6.31 ± 0.2	9.45 ± 0.3	10.45 ± 0.2
	T5	1.82 ± 0.00	6.50 ± 0.05	10.75 ± 0.0	10.75 ± 0.00
	T6	3.28 ± 0.1	8.54 ± 0.2	6.63 ± 0.01	10.63 ± 0.01
	T7	1.09 ± 0.04	6.35 ± 0.3	6.73 ± 0.0	10.68 ± 0.00

minimum fluctuations during storage as compared to other samples. On the contrary, Guar gum at 1% was found to have marginal protective effect on color parameters, while higher concentrations adversely affected the color during storage. According to Cross *et al* (1986) and Garcia-Segovia *et al* (2007), during heating, myoglobin and haemoglobin is converted to metmyoglobin - the brown colored oxidized form of myoglobin. Several reports suggest that gum Acacia has antioxidant capacity (Trommer *et al*, 2005; Ali *et al*, 2009; Hinson *et al*, 2004). The maximum L* values observed in T7 may probably be due to this antioxidant activity against pigment oxidation.

Texture profile analysis (TPA): Texture profile analysis of the fried fish nuggets were determined and expressed in terms of hardness, cohesiveness, springiness, gumminess, chewiness and resilience values, respectively. In general, addition of gums imparted fluidity and softness to the treated samples compared to the rigid structure of untreated samples. The results indicated that control sample had significantly ($p < 0.05$) higher hardness value among all freshly prepared formulations (Table 5). Addition of Guar gum reduced the hardness values to almost one fifth, whereas gum Acacia reduced the value to half of that of nuggets without any gum. Higher springiness values were recorded for treated samples, especially towards the latter period of storage. During heating, the incorporation of a right ratio of hydrocolloid to meat protein plays an important role in enhancing binding of water molecules in protein, resulting in softer, juicier protein systems which may be desirable in some food products (Nasiri *et al*, 2011). Texture profile analysis (TPA) of par-fried and full fried products show that shrimp nuggets containing both ß-glucan and carboxy methyl cellulose (BG+CMC formulation) had significantly higher springiness, chewiness and cohesiveness than control ($p < 0.05$) and lower hardness and shear force values (Haghshenas *et al*, 2014). Nuggets containing gum Acacia at 2% level had significantly higher chewiness values than other formulations during storage ($p < 0.05$). Protein–carbohydrate interactions affect the functional properties of muscle foods where proteins are the major ingredients. Guar gum and gum Arabic are commonly employed to thicken and impart stickiness to aqueous dispersions (Saha, 2010). Unlike in gelling process which involves the cross-linking of polymer chains to form three dimensional networks that immobilizes the water within it to form a rigid structure that is resistant to flow, the process of thickening involves the non-specific entanglement of conformationally disordered polymer chains (Philips *et al*, 1986) During deep frying, muscle proteins undergo random aggregation with simultaneous expulsion of bound water resulting in a hard textured product. The soft and tender texture of nuggets incorporated with gums observed in the present study could be associated with the reduction in

Table 5: Texture Profile Analysis (TPA) of fish nuggets during various storage periods

Storage	Treatments	Hardness	Springiness	Cohesiveness	Guminess	Chewiness	Resilence
0 DAY	T1 (control)	2376.11 ± 5.65	0.60 ± 0.02	0.67 ± 0.00	460 ± 0.47	281 ± 0.19	0.26 ± 0.14
	T2	457.88 ± 7.35	0.66± 0.00	0.84 ± 0.07	386.56 ± 1.96	255.50 ± 1.35	0.43 ± 0.04
	T3	765.39 ± 3.53	0.62 ± 0.00	0.45 ± 0.05	297.04 ± 1.82	270 ± 1.42	0.18 ± 0.1
	T4	680.02 ± 0.73	0.5 ± 0.1	0.55 ± 0.05	403.67 ± 1.41	200.90 ± 0.60	0.19 ± 0.02
	T5	1585.34 ± 1.79	0.81 ± 0.002	0.62 ± 0.00	853.50 ± 1.80	765.15 ± 1.37	0.21 ± 0.00
	T6	1049.63 ± 0.67	0.6± 0.2	0.67 ± 0.01	764.41 ± 2.75	476.25 ± 1.75	0.25 ± 0.00
	T7	1233.72 ± 1.06	0.54 ± 0.06	0.66 ± 0.02	1085.35± 1.25	646.7 ± 1.99	0.27 ± 0.01
15 DAYS	T1 (control)	2196.12 ± 1.34	0.56 ± 0.01	0.87 ± 0.03	1965.67 ± 1.49	1088.04 ± 0.62	0.38 ± 0.01
	T2	1608.41 ± 0.86	0.53 ± 0.03	0.90 ± 0.02	1575.43 ± 0.96	722.83 ± 0.85	0.33 ± 0.01
	T3	676.86 ± 1.21	0.44 ± 0.02	0.86 ± 0.03	557.15 ± 1.04	226.59 ± 1.27	0.31 ± 0.01
	T4	790.87 ± 1.79	0.49 ± 0.03	0.85 ± 0.02	643.34 ± 2.86	323.18 ± 1.67	0.29 ± 0.02
	T5	1761.11 ± 1.42	0.56 ± 0.00	0.89 ± 0.00	1666.56 ± 1.86	968.01 ± 0.88	0.33 ± 0.02
	T6	1493.65± 1.66	0.64 ± 0.03	0.84 ± 0.002	736.67± 3.01	736.67 ± 3.01	0.29 ± 0.01
	T7	2664.21± 1.03	0.74 ± 0.02	0.86 ± 0.03	1562.91 ± 0.96	1562.91 ± 0.96	0.31 ± 0.01
30 DAYS	T1 (control)	2470.88 ± 0.4	0.59 ± 0.03	0.67 ± 0.00	1772.6 ± 1.52	1059.00 ± 1.37	0.26 ± 0.01
	T2	1276.14± 1.22	0.61 ± 0.02	0.53 ± 0.04	705.49 ± 1.61	468.08 ± 0.43	0.16 ± 0.02
	T3	1644.22 ± 1.35	0.61 ± 0.02	0.83 ± 0.00	1141.15 ± 0.46	765.32 ± 0.68	0.17 ± 0.00
	T4	1886.26 ± 1.4	0.67 ± 0.01	0.49 ± 0.01	917.9 ± 1.08	611.09 ± 1.06	0.15 ± 0.01
	T5	1812.35 ± 1.40	0.73 ± 0.01	0.58 ± 0.02	1186.83 ± 1.41	765.8 ± 0.77	0.20 ± 0.02
	T6	2630.95 ± 0.77	0.61 ± 0.01	0.62 ± 0.03	2244.36 ±0.60	1311.67 ±0.49	0.23 ± 0.03
	T7	3560.04 ± 1.37	0.84 ± 0.63	0.59 ± 0.01	2082.41 ± 1.78	1763.03 ±1.44	0.19 ± 0.00
60 DAYS	T1 (control)	2474.51 ± 0.7	0.64 ± 0.01	0.71 ± 0.01	1759.11 ± 1.42	1049.61 ± 0.71	0.28 ± 0.00
	T2	2455.03 ± 1.37	0.65 ± 0.01	0.63 ± 0.00	1829.60 ± 1.42	1348.46 ± 1.68	0.19 ± 0.01
	T3	1497.91 ± 1.60	0.46 ± 0.02	0.5 ± 0.01	989.51 ± 0.8	514.96 ± 1.35	0.19 ± 0.02
	T4	1898.62 ± 0.71	0.68 ± 0.00	0.51 ± 0.01	929.61 ± 0.71	619.63 ± 0.71	0.18 ± 0.01
	T5	1121.57 ± 0.6	0.79 ± 0.00	0.57 ± 0.01	612.7 ± 0.7	560.47 ± 0.8	0.23 ± 0.01
	T6	1330.01 ± 0.13	0.86 ± 0.01	0.74 ± 0.06	734.83 ± 0.87	577.52 ± 0.71	0.21 ± 0.01
	T7	1964.67 ± 0.77	0.75 ± 0.01	0.84 ± 0.01	1171.08 ± 0.63	1014.74 ± 0.72	0.31 ± 0.01

Table 6: Sensory analysis of fish nuggets at various storage periods

STORAGE	Treatments	Color	Flavor	Taste	Texture	Stickiness	Appearance	Overall Acceptibiltity
0 DAY	T1 (control)	7.6 ± 0.8	7.4 ± 0.8	7.6 ± 0.8	7.8 ± 0.8	7.4 ± 0.8	7.4 ± 0.8	7.5 ± 0.8
	T2	6.8 ± 0.4	7.4 ± 0.5	7.4 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	7.4 ± 0.8	7.0 ± 0.8
	T3	6.8 ± 0.4	7.6 ± 0.5	7.4 ± 0.8	6.2 ± 0.8	6.4 ± 0.8	7.4 ± 0.8	6.9 ± 0.8
	T4	7.4 ± 0.5	7.6 ± 0.5	7.6 ± 0.8	7.4 ± 0.8	7.0 ± 0.7	7.0 ± 0.7	7.3 ± 0.8
	T5	7.6 ± 0.8	7.8 ± 0.7	7.6 ± 0.8	8.0 ± 0.7	7.8 ± 0.4	7.6 ± 0.8	7.7 ± 0.5
	T6	7.8 ± 0.8	7.6 ± 0.5	7.2 ± 0.8	7.8 ± 0.8	7.6 ± 0.8	7.2 ± 0.4	7.6 ± 0.8
	T7	7.8 ± 0.8	8.0 ± 0.5	7.8 ± 0.8	8.0 ± 0.7	7.6 ± 0.5	7.6 ± 0.8	7.8 ± 0.8
15 DAYS	T1 (control)	6.6 ± 0.8	6.6 ± 0.5	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	7.3 ± 0.8	5.6 ± 0.5
	T2	7.1 ± 0.9	7.5 ± 0.5	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	7.5 ± 0.8	7.0 ± 0.6
	T3	6.8 ± 0.7	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	7.1 ± 0.7	6.7 ± 0.7
	T4	8.0 ± 0.6	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	7.8 ± 0.7	6.9 ± 0.4
	T5	7.1 ± 0.7	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	7.6 ± 0.8	6.9 ± 0.9
	T6	7.0 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	7.8 ± 0.9	6.9 ± 0.8
	T7	7.3 ± 0.5	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	6.6 ± 0.8	7.8 ± 0.9	6.9 ± 0.8
30 DAYS	T1 (control)	7.1 ± 0.4	7.8 ± 0.7	7.3 ± 0.7	7.3 ± 0.5	7.6 ± 0.5	7.6 ± 0.5	7.5 ± 0.4
	T2	7.1 ± 0.4	7.6 ± 0.8	7.6± 0.5	7.5 ± 0.5	7.3 ± 0.5	7.6 ± 0.5	7.5 ± 0.5
	T3	7.3 ± 0.5	7.1 ± 0.4	7.1± 0.4	7.6 ± 0.5	7.1 ± 0.4	7.6 ± 0.5	7.3 ± 0.8
	T4	7.0 ± 0.1	7.0 ±0.01	6.0±0.1	8.0 ± 0.1	7.0 ± 0.1	8.0 ± 0.2	7.2 ± 0.2
	T5	7.3 ± 0.5	7.0 ± 0	7.3± 0.5	7.6 ± 0.8	7.0± 0.8	7.3 ± 0.5	7.3 ± 0.4
	T6	7.8 ± 0.4	7.8 ± 0.4	7.5 ± 0.5	7.6 ± 0.5	7.6 ± 0.5	8.0 ± 0.6	7.7 ± 0.5
	T7	7.5 ± 0.5	7.5 ± 0.5	7.6± 0.5	7.5 ± 0.5	7.3 ± 0.5	8.0 ± 0.6	7.6 ± 0.5
60 DAYS	T1 (control)	7.1 ± 0.1	7.7 ± 0.2	7.6 ± 0.1	7.2 ± 0.2	7.5 ± 0.1	7.5 ± 0.2	7.4 ± 0.1
	T2	6.5 ± 0.01	6.7 ± 0.1	7.6 ± 0.1	7.3 ± 0.1	7.4 ± 0.2	7.6 ± 0.1	7.2 ± 0.1
	T3	7.2 ± 0.1	7.3 ± 0.2	7.8 ±0.01	7.5 ± 0.1	7.7 ± 0.2	7.9 ± 0.1	7.6 ± 0.02
	T4	7.3 ± 0.1	7.2 ± 0.2	7.2 ± 0.3	7.6 ± 0.4	7.8 ± 0.01	7.9 ± 0.2	7.5 ± 0.1
	T5	7.6 ± 0.3	7.1 ± 0.1	7.2 ± 0.2	7.2 ± 0.1	7.4 ± 0.2	7.4 ± 0.1	7.3 ± 0.01
	T6	7.9 ± 0.1	7.9 ± 0.2	7.7 ±0.01	7.5 ± 0.2	7.8 ± 0.5	7.7 ± 0.2	7.8 ± 0.01
	T7	7.6 ± 0.1	7.5 ± 0.1	7.8 ± 0.2	7.9 ± 0.01	7.6 ± 0.2	7.8 ± 0.1	7.7 ± 0.2

protein self-aggregation by occupying the interstitial moisture lattices with the viscous gum solution which in turn reduces the resistance to compression. During the initial days of sampling, the cohesiveness values were higher for nuggets with 1% Guar gum; however towards the latter period of storage, gum Acacia at 1.5-2% excelled. Cohesiveness is the ratio of the areas of force curve under the first and second compressions, which is the amount of deformation of the food before it is disjoint. As the value is closer to 1, the object has more elastic properties. There is a cut-off point, above which the texture of nuggets becomes unacceptable (Bourne, 1978) Therefore, determination of good textural qualities of nuggets should be done together with a sensory test in order to find out the most suitable range preferred by consumer (Feng *et al*, 2003).

Sensory evaluation: The sensorial characteristics of nuggets samples are depicted in Table 6. Based on 9 point Hedonic scale (1=dislike extremely, 9=like extremely), the overall acceptability of control and gum incorporated fish nuggets were not significantly different ($p < 0.05$), indicating that the addition of gums did not change product acceptance by consumers. However, the panelists had significantly higher preference for the color, texture and flavour of fried fish nuggets found in sample with 2% gum Acacia. Incorporation of gums did not impart any additional stickiness to the product. In general, gum Acacia retained the sensory acceptability of the fish nuggets better during the storage.

CONCLUSION

Proximate analysis, microbial assay, color, textural properties and sensory evaluation tests on fish nuggets, containing varying amounts of vegetable gums were significantly different from that of control. These differences were obviously due to variation in gum and their concentrations in the compositions. The results obtained in this study showed that incorporation of gum Acacia may be advocated in fish nugget formulations, not only as binding and texturizing agents, but also as an active ingredient for reducing fat content, without compromising the optimum texture and sensory attributes of the processed fish nuggets.

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REFERENCES

Ali, B. H., Ziada, A. and Blunden, G. (2009) Biological effects of gum Arabic: A review of some recent research. *Food Chem. Toxicol*. **47:** 1-8.

Ang, J. and Miller, W. (1991) Multiple functions of powdered cellulose as a food ingredient. *Cereal Foods World*. **36:** 558-564.

Anonymous (2011) Official for regulation of *Pangasius* fish culture, *The Hindu*, AP Edition, Eluru, India. (assessed March, 2015).

AOAC (2005) *Official Methods of Analysis*, 18th edition, Association of Official Analytical Chemists, Washington, DC, USA.

Bajaj, I. and Singhal, R. (2007). Gellan gum for reducing oil uptake in *sev*, a legume based product during deep-fat frying. *Food Chem*. **104:** 1472-1477.

Balachandran, K. (2001). *Post-harvest Technology of Fish and Fish Products*; Daya Books, New Delhi, 271 – 287.

Bourne, M. C. (1978). Texture profile analysis. *J. Food Sc.* **32:** 62–67.

CIE, (2008). CIE L*a*b* Color Scale, *Application Note* 8(7), Hunter Assoc. Laboratory, Virginia, USA.

Cross, H.R., Durland, P.R. and Seideman, S.C. (1986). Sensory qualities of meat, *In* Bechtel P.J. (ed.). *Muscle as Food*. Harcourt Brace Jovanovics, Orlando, F.L, USA, 279-320.

Feng, J.; Xiong, Y.; Mikel, W. (2003). Textural properties of pork frankfurters containing thermally / enzymatically modified soy proteins. *J Food Sc*. **68:** 1220-1224.

Foegeding, E.A. and Ramsey, S.R. (1987). Rheological and water holding properties of gelled meat batters containing iota carrageenan, kappa carrageenan or xanthan gum. *J. Food Sci*. **52:**549-553.

FSSAI. (2012). *Manual of Methods of Analysis of Foods*, Ministry of Health and Family Welfare, Govt. of India, New Delhi. 1-19.

García-Segovia, P., Andrés-Bello, A. and Martínez-Monzó, J. (2007). Effect of cooking method on mechanical properties, color and structure of beef muscle (m. pectoralis). *J. Food Engg*. **80:** 813-821.

Gennadios, A., Hanna, M. A. and Kurth, L. B. (1997). Application of edible coatings on meats, poultry and seafoods: A review. *LWT-Food Sc. Technol*. **30:** 337-350.

Haghshenas, M., Hosseini, H., Nayebzadeh, K., Khanghah, A. M., Kakesh, B. S., and Fonood, R. K. (2014). Production of prebiotic functional shrimp nuggets using ß-glucan and reduction of oil absorption by carboxymethyl cellulose: Impacts on sensory and physical properties. *J. Aquacul. Res. Dev*. **5:** 245-248.

Hinson, J. A., Reid, A. B., McCullough, S. S. and James, L. P. (2004). Acetaminophen - induced hepatotoxicity: Role of metabolic activation, reactive oxygen / nitrogen species, and mitochondrial permeability transition. *Drug Metabolism Rev*, **36:** 805-822.

Nasiri, F. D., Mohebbi, M., Yazdi, F. T. and Khodaparast, M. H. (2011). Kinetic modeling of mass transfer during deep fat frying of shrimp nugget prepared without a pre-frying step. *Food and Bio-products Processing*, **89:** 241-247.

Osman, M. E., Williams, P. A., Menzies, A. R. and Phillips, G. O. (1993). Characterization of commercial samples of gum Arabic. *J. Agricul. Food Chem*. **41:** 71-77.

Panda, H. (2010). *The Complete Book on Gums and Stabilizers for Food Industry*; Asia Pacific Business Press Inc., New Delhi, 1 – 470.

Philips, G.O., Wedlock, D.J. and Williams, P.A. (1986). Molecular origin of hydrocolloid functionality. *In Gums and Stabilizers for the Food Industry*, Philips G.O., Williams, P.A and Wedlock, DJ, (eds.). IRL Press Oxford. **3:** 3–5.

Pinthus, E. J. and Saguy, I.S. (1994). Initial interfacial tension and oil uptake by deep fat fried foods. *J. Food Sc*. **59:** 804-807.

Rario. (2015). Test of preference level for catfish (*Pangasius pangasius*) nugget from central Kalimantan with different filler material, *Int. J. Curr. Res. Acad. Rev*. **3:** 186-195.

Sabahelkheir, M.K., Abdalla, A.H. and Nouri, S. (2012). Quality assessment of Guar gum (endosperm) of Guar (*Cyamopsis tetragonoloba*). *ISCA J. Biol. Sci*.**1:** 67-70.

Saha, D. and Bhattacharya, S. (2010). Hydrocolloids as thickening and gelling agents in food: A critical review. *J. Food Sc. Technol*. **47:** 587-597.

Shabanpour, B. and Jamshidi, A. (2013). Quality characteristics of fried rainbow trout (*Oncorhynchus mykiss*) fillets coated with different hydrocolloids edible films, *World J. Fish Marine Sci*., **5:** 398 – 404.

Sun, J., Li, X., Xu, X. and Zhou, G. (2011). Influence of various levels of flaxseed gum addition on the water holding capacities of heat induced porcine myofibrillar protein, *J. Food Sci*. **76:** 472-478.

Trommer, H. and Neubert, R. H. (2005). The examination of polysaccharides as potential antioxidative compounds for topical administration using a lipid model system. *Int. J. Pharma*. **298:** 153-163.

Yoon, S. J., Chu, D. C. and Juneja, R.L. (2008). Chemical and physical properties, safety and application of partially hydrolized Guar gum as dietary fiber. *J. Clin. Biochem. Nutr.* **42:** 1-7.