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Effect of Hydrocolloids as an Ingredient of Batter Mix on the Biochemical, Physical and Sensory Properties of Frozen Stored Coated Shrimp

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Coated shrimp was prepared using three different hydrocolloid incorporated batter systems viz., Guar Gum (GG), Carboxy Methyl Cellulose (CMC) and Carboxy Methyl Chitosan (CMT). The effect of incorporation of these hydrocolloids on the biochemical, physical and sensory characteristics of coated shrimp and changes during frozen storage at -20 ^{0}C for 5 months were studied. Highest pickup (40%) was observed for GG based batter, followed by CMC (34%) and CMT (32%). GG based batter showed maximum uptake of fat, both after prefrying and deep frying. Peroxide value, free fatty acid and thiobarbituric acid value were at insignificant levels in products during the frozen storage. The values for textural parameters of the coated products showed a decline after one month of frozen storage and thereafter the values remained almost stable. The sensory evaluation of the coated products during frozen storage indicated that those coated with CMC based batter had a superior overall acceptability compared to the other two. The total bacterial count was almost steady during frozen storage and it was in the intermediate count level. Among the three different hydrocolloids, CMC based batter system was found to provide superior sensory qualities, maximum moisture retention capacity and minimum fat uptake to the coated shrimp.

Key words : Batter mix, coated shrimp, guar gum, carboxy methyl cellulose, carboxy methyl chitosan, pickup

Development of value added fishery products is a rewarding task for the seafood processing industry with multiple benefits from the value chain of the process involved. Among the value added products, most prominent and lucrative one is the coated product. Quality of coated product generally depends on various factors such as appearance, colour, crispness, adhesion, flavour, pickup, cooking time, method of cooking and microbial load. Ingredients give coating their unique characteristics and functionalities. The primary use of hydrocolloids in batter has been based on their capacity to immobilize water and their effect on viscosity. Gums and starches are the most important types of hydrocolloids. Improvements in shelf life and eating quality have been observed in fried products containing hydrocolloids in both the substrate and coating system (Harris & Lee, 1974; Suderman, 1983; Anon, 1985; Baker & Scott-Kline, 1988; D' Amico et al., 1988). Hydrocolloids viz., Carboxy Methyl Cellulose (CMC), Guar Gum (GG) and Carboxy Methyl Chitosan (CMT) improve the functional properties of food coatings. The aim of this study was to evaluate the effect of incorporation of these hydrocolloids in batter mix on the biochemical, physical and sensory characteristics of frozen stored coated shrimp.

Materials and Methods

Freshly caught shrimps, *Fenneropenaeus indicus* of 16-20 size count (weighing 16 to 20 shrimps per kg) procured from a farm near Cochin were used for the study. Immediately after catch, the shrimps were properly washed with potable water, iced and brought to the laboratory in insulated boxes.

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The ingredients of the batter were mixed thoroughly using a homogenizer (Model Euro turrax-T 25b - IKA LABORTECHNIK) for two minutes (Table 1). The hydrocolloids viz., Guar gum, Carboxy Methyl Cellulose and Carboxy Methyl Chitosan were added at O.96% level. These coatings were designated as Lot I, Lot II and Lot III respectively. The selection of the hydrocolloids was made based on a previous study by Abbas et al. (2OO9).

Table 1. Ingredients of batter mix

Materials	Weight/100 g
Maida (Flour)	77.50
Corn flour	9.70
Bengal gram powder	9.70
Salt	1.20
Sodium tri polyphosphate	0.47
Turmeric powder	0.47
Hydrocolloids (GG/CMC/CMT)*	0.96

Source: Abbas et al.(2009)

*The typical level for the use of hydrocolloid in batter systems is 0.5 to 1% range (w/w, flour basis)

The breadcrumbs were prepared from locally available sliced bread. The crust free loaves were blended for one minute, dried in an air oven to a moisture level below 5% and sieved to obtain uniform crumbs with a particle size of 400-500 µm.

The shrimps were peeled, de-veined and frozen in an air blast freezer (Model Icematic T 1O) at -4O^{o}C for 30 minutes as individually quick frozen pieces, weighed and stored at -2O^{o}C prior to coating. The batters prepared were mixed with water in the ratio of 1:2 (W/V) for 2 minutes. The frozen peeled and deveined (PD) shrimps were pre-dusted, battered, breaded and the total weight was noted. It was prefried in refined sunflower oil (3O sec. at 18O^{o}C), blast frozen at - 40^{o}C for 30 minutes, packed in polyester/polypropylene pouches and stored at - 2O^{o}C. The flow chart for preparation of coated shrimp is given in Fig. 1. The pickup and product yield of coated shrimp was calculated as follows.

Pickup % =

$$\frac{\text{(Coated weight – raw weight)}}{\text{Coated weight}} \times 100$$

Product Yield (%) =

$$\frac{\text{Weight of finished product}}{\text{Initial weight}} \times 100$$

Prefried, frozen stored samples were thawed at room temperature for 20 minutes and used for the Texture Profile Analysis by a Food Texture Analyzer (Lloyd Instruments, Model LRX Plus, UK). The test was carried

Raw material (fresh shrimp)

Washing

Peeling & Deveining

Washing

Freezing

Pre-dusting

Battering

Breading

Prefrying

Blast freezing (- 40^{0}C)

Packing in polyethylene pouches

Storing (-20^{0}C)

Fig. 1. Flow chart for preparation of coated shrimp.

out at a speed of 12 mm/min. using a 500 N load cell and a cylindrical probe of 50 mm dia. Uniform samples were compressed to 40% with a trigger force of 0.5 kg. From the double compressions, parameters such as hardness 1, hardness 2, cohesiveness, springiness, and fracture force were determined. Texture profile analysis results were tabulated using Nexygen Software. The changes in moisture content and fat content of prefried and deep fried (for 3 min and 5 min) samples were estimated.

Colorimetric analysis of prefried and deep fried (3 min.) minced samples was performed with a Hunter lab Miniscan ® XE plus Spectrocolorimeter (Hunter Associates Laboratory, Inc. Reston, Virginia, USA). Measurements were recorded using the L* a* b* colour scale (CIE, 1986).

Prefried, frozen stored samples were used for the following analyses. Moisture, ash, total nitrogen and crude fat were determined using AOAC methods 950.46, 938.08 940.25 and 991.36 (AOAC, 2000) respectively. Thiobarbituric Acid (TBA) value was determined by the method of Tarladgis et al. (1960), peroxide value (PV) and free fatty acid (FFA) were determined according to AOCS (1989) and AOAC (2000) respectively. The total cholesterol was estimated as per Parekh & Jung (1970). Total plate count was determined as per Hitching et al. (1995). Analytical grade reagents supplied by E Merck (Damstardt, Germany) and Sigma (St. Louis, USA) were used for the experiments.

Prefried, frozen stored samples were thawed at room temperature for 20 minutes and deep fried for 3 minutes and presented to a group of five panelists for organoleptic evaluation. The overall acceptability was assessed on the basis of nine-point hedonic scale as described by Peryam & Pilgrims (1957). The scores for each attribute were pooled and averages are presented. A score of 4 was taken as the limit of acceptance.

Significance of variance was tested by ANOVA and Duncan's Multiple Range tests using SPSS, 10.0.

Results and Discussion

The yield and pickup at different stages of coating based on whole shrimp and PD shrimp are given in Table 2. The yield of PD

Table 2. Yield and pickup of coated shrimp products at different stages of coating*

Products	Yield based on whole shrimp (%)			
	PD shrimp	Pre-dusted	Battered & Breaded	Prefried
Lot I	49.8 ± 0.1	51.8 ± 0.2[a]	83.0 ± 0.4[a]	85.1 ± 0.5[a]
Lot II	49.8 ± 0.1	51.7 ± 0.4[a]	75.7 ± 0.6[b]	79.7 ± 0.2[b]
Lot III	49.8 ± 0.1	51.9 ± 0.2[a]	74.9 ± 0.4[b]	78.4 ± 0.8[b]
	Yield based on PD shrimp (%)			
Lot I	—	104.2 ± 0.3[a]	166.7 ± 0.6[a]	170.8 ± 0.8[a]
Lot II	—	104.0 ± 0.2[a]	152.0 ± 0.2[b]	160.0 ± 0.4[b]
Lot III	—	104.4 ± 0.5[a]	147.8 ± 0.4[c]	156.5 ± 0.4[c]
	Pickup based on PD shrimp (%)			
Lot I	—	4.0 ± 0.2[a]	40.0 ± 0.4[a]	41.5 ± 0.4[a]
Lot II	—	3.9 ± 0.5[a]	34.2 ± 0.3[b]	37.5 ± 0.6[b]
Lot III	—	4.2 ± 0.2[a]	32.4 ± 0.5[c]	36.1 ± 0.8[b]

* Different superscripts in the same column indicate significant differences ($p < 0.05$)

shrimp from whole raw shrimps was 49.8%. Lot I samples had higher yields at different stages of coating viz., pre-dusting, battering and breading and prefrying. Substantially higher pickup (4O%) was observed in Lot I, followed by Lot II (34%) and Lot III (32%). The same trend was observed for all the three hydrocolloid based batters after prefrying of the coated products. The coating pickup is an important physical property since it affects quality parameters of fried foods. Coating pick up is directly related to batter viscosity i.e., as viscosity increases more batter remains on the sample (Altunakar et al., 2OO4; Dogan, 2OO4). The viscosity of the batter systems affects the pickup and quality of the batter that adheres, the handling properties of the battered product, its appearance and its final texture (Fiszman & Salvadore, 2OO3). Correlation between viscosity and adhesion of the batter to the food was reported by Hisa et al. (1992) in batters formulated with xanthan gum, guar gum and CMC at different concentrations.

Moisture content and fat uptake of fried shrimps coated with batters containing three different hydrocolloids at different frying times are given in Table 3. Prolonged frying indicated a progressive decrease in the moisture content for all the three samples. Higher moisture retention was observed in Lot II samples. Loewe (1992) observed that film formation and thermal gelation abilities are critical functions of gums for barrier properties, moisture retention and fat uptake. The higher moisture retention capacity of Lot II could be due to its higher water binding capacity. Lot I samples showed maximum uptake of fat after prefrying and deep frying. Lot II and Lot III samples showed almost the same fat uptake after prefrying for 3O seconds and deep frying for 5 minutes. The minimum uptake of fat observed in Lot II after 3 minutes of frying could be due to the film formation after prefrying. However, there was an increase in fat absorption after frying for 5 minutes, probably due to the disintegration of the film formed. The film forming capacity of Lot III was not as effective as that of Lot II which could be the reason for the maximum fat uptake after 3 minutes of frying. The gelling ability and hydrophilic nature of hydrocolloids make them suitable for reducing oil uptake during frying of battered products (Annapure et. al., 1999).

The prefried coated shrimp had a moisture content of 59.29%, 12.2% protein, 13.18% fat, 1.23% ash and 2O.8 mg/1OO g cholesterol. The rancidity indices viz., PV, FFA and TBA were at very low levels in the samples during the period of frozen storage

Table 3. Changes in moisture content and fat content of coated shrimp during frying at different time intervals

	Moisture content (%)		
Products	30 seconds	3 minutes	5 minutes
Lot I	59.29 ± 0.9[a]	50.31 ± 0.4[a]	38.82 ± 0.2[a]
Lot II	60.34 ± 0.4[a]	54.09 ± 0.7[b]	44.47 ± 0.6[b]
Lot III	59.71 ± 0.4[a]	52.56 ± 0.2[c]	42.86 ± 0.4[c]
	Fat uptake (%)		
Lot I	33.10 ± 0.8[a]	33.92 ± 0.2[a]	34.25 ± 0.4[a]
Lot II	29.84 ± 0.2[b]	28.62 ± 0.6[b]	29.88 ± 0.2[b]
Lot III	30.01 ± 0.4[b]	31.02 ± 0.3[c]	30.01 ± 0.4[b]

Different superscripts in the same column indicate significant differences ($p < 0.05$)

(Table 4). This could be due to the barrier properties of coatings which prevented the oxidative rancidity.

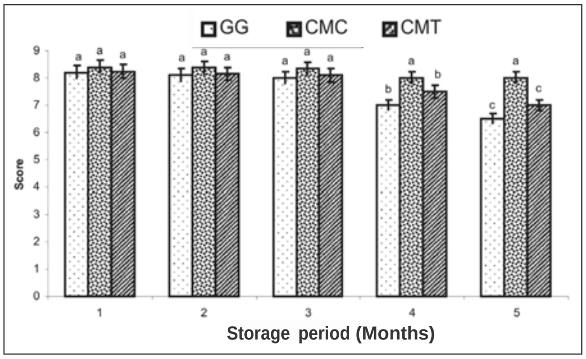
Significantly higher ($p < 0.05$) L* value for prefried and deep fried products was observed in Lot II (Table 5). The lighter color indicates that the product absorbed less oil (Loewe, 1992). The CMC added batter gave more luminosity to the Lot II samples as it helped to retain more moisture and absorbed less oil than the other two hydrocolloids. Lot I indicated least luminosity, since it absorbed higher amount of oil than the other two hydrocolloids during prefrying and deep frying. GG incorporated batter imparted higher redness (a*) and yellowness (b*) to prefried and deep fried coated shrimp. The highest value of a* and b* in the case of Lot I may be due to the higher absorption of oil during frying and its lowest capacity to retain moisture. Baker et al. (1972) reported that cooking method is a factor that can affect the color of the product.

Hardness 1 and hardness 2 values (Table 6) were maximum for Lot II (5.39 kgf and 4.59 kgf. respectively) which may be due to the better cross-linking properties of CMC. The lowest springiness of O.32 mm was observed in Lot I while in Lot III it was O.33 mm. Lot II samples had the highest level of springiness of O.34 mm. Lot I showed a high fracture force of 4.86 N, followed by Lot III and Lot II. During frozen storage, initial hardness 1 value of Lot I was 5.25 kgf which decreased to 3.9 kgf after one month of storage and remained constant during the rest of the storage period. However, in the case of Lot II there were no changes in the hardness values during the storage. Lot III samples showed a decrease in the hardness 1 value in the second month of storage. An initial decrease in the hardness 2 value was noted in Lot I and Lot III during storage. Lot III had highest cohesiveness value of O.37. In Lot II samples, fracture force showed an increasing trend during frozen storage.

The sensory scores of coated shrimp products during frozen storage are given in Fig 2. Lot II samples had a desirable golden brown colour and a better appearance with an overall sensory score of 8.4. During the initial three months of storage, the overall sensory scores for all the products remained

Table 4. Changes in PV, FFA and TBA during frozen storage of coated shrimp products

	Peroxide value (millequivalent/kg fat)				
DAYS	30	60	90	120	150
Lot I	1.74 ± 0.03	1.78 ± 0.08	1.80 ± 0.06	1.88 ± 0.02	1.86 ± 0.01
Lot II	1.72 ± 0.02	1.77 ± 0.04	1.79 ± 0.03	1.86 ± 0.03	1.80 ± 0.04
Lot III	1.56 ± 0.05	1.62 ± 0.02	1.70 ± 0.05	1.84 ± 0.03	1.80 ± 0.07
	Free Fatty acid value (mg% oleic acid)				
Lot I	1.48 ± 0.03	1.23 ± 0.07	1.75 ± 0.02	1.62 ± 0.01	0.96 ± 0.05
Lot II	1.01 ± 0.01	1.20 ± 0.02	1.21 ± 0.08	1.41 ± 0.04	1.20 ± 0.03
Lot III	1.15 ± 0.04	1.21 ± 0.01	1.64 ± 0.04	1.40 ± 0.03	1.11 ± 0.08
	Thiobarbituric acid value (mg malonaldehyde/kg fat)				
Lot I	0.21 ± 0.01	0.25 ± 0.02	0.34 ± 0.01	0.30 ± 0.01	0.31 ± 0.06
Lot II	0.30 ± 0.01	0.32 ± 0.02	0.36 ± 0.01	0.31 ± 0.02	0.28± 0.02
Lot III	0.37 ± 0.02	0.42 ± 0.03	0.46 ± 0.04	0.46 ± 0.05	0.40 ± 0.06

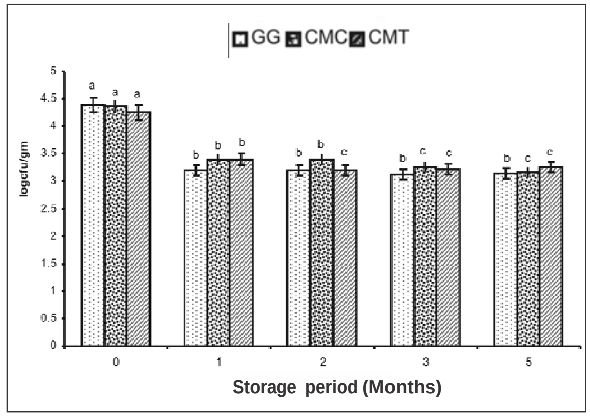


Different superscripts in similarly marked columns indicate significant differences (p<0.05)

Fig. 2. Sensory score of coated shrimp products during frozen storage

above 8 indicating high acceptability. After three months of storage, Lot I samples showed slight loss in crispness. A coating should ideally be crispy, i.e., it should exhibit a sufficient resistance to the initial bite and then disappear as a quick melt away in the mouth. (Loewe, 1992). Lot II retained superior overall acceptability throughout the frozen storage period. Significant ($p<0.05$) reduction in the overall acceptability scores was noted in the case of Lot I and Lot III from the fourth month onwards.

The total bacterial count (Fig. 3) showed a significant reduction after one month of frozen storage and thereafter remained almost stable. This may be due to the initial destruction of natural flora on blast freezing at - 40°C. In the present study the total plate count of the products remained in acceptable level during 5 months of frozen storage.



Different superscripts in similarly marked columns indicate significant differences (p<0.05)

Fig. 3. Bacterial load of the coated shrimp products during frozen storage

Among the coated shrimp products prepared using three different hydrocolloid based batter systems, the highest pickup (40%) was found in Guar gum incorporated sample, followed by Carboxy Methyl Cellulose (34%) and Carboxy Methyl Chitosan (32%) incorporated samples. Maximum yield for the coated shrimp was observed when Guar Gum based batter was used for coating. Guar gum incorporated sample showed maximum uptake of fat, both after prefrying and deep frying. Carboxy Methyl Cellulose

Table 5. L* a* b* values of coated shrimp products

Product	Prefried shrimp (30 sec)		
	L *	a*	b*
Lot I	57.2 ± 0.6 [a]	3.9 ± 0.2 [a]	20.1 ± 0.5 [a]
Lot II	61.5 ± 0.8 [b]	2.6 ± 0.5 [b]	18.3 ± 0.2 [b]
Lot III	58.3 ± 0.7 [a]	3.2 ± 0.4 [b]	19.2 ± 0.2 [c]
	Deep fried shrimp (3 min)		
Lot I	48.3 ± 0.8 [a]	7.2 ± 0.2 [a]	28.5 ± 0.2 [a]
Lot II	52.3 ± 0.4 [b]	6.2 ± 0.4 [b]	19.4 ± 0.6 [b]
Lot III	50.2 ± 0.2 [c]	6.6 ± 0.4 [b]	27.3 ± 0.4 [c]

Different superscripts in the same column indicate significant differences ($p<0.05$).

Table 6. Texture parameters of coated shrimp products during frozen storage

	Hardness 1 (kgf)				
DAYS	30	60	90	120	150
Lot I	5.25 ± 0.05 [a]	3.90 ± 0.04 [a]	3.91 ± 0.06 [a]	3.92 ± 0.07 [a]	3.88 ± 0.08 [a]
Lot II	5.39 ± 0.03 [b]	5.25 ± 0.02 [b]	5.22 ± 0.08 [b]	5.22 ± 0.1 [b]	5.20 ± 0.04 [b]
Lot III	5.36 ± 0.02 [b]	4.34 ± 0.05 [c]	4.32 ± 0.16 [c]	4.31 ± 0.04 [c]	4.31 ± 0.11 [c]
	Hardness 2 (kgf)				
Lot I	4.45 ± 0.06 [a]	3.13 ± 0.02 [a]	3.23 ± 0.04 [a]	3.20 ± 0.03 [a]	3.11 ± 0.05 [a]
Lot II	4.59 ± 0.02 [b]	4.58 ± 0.05 [b]	4.58 ± 0.02 [b]	4.21 ± 0.06 [b]	4.20 ± 0.03 [b]
Lot III	4.53 ± 0.07 [b]	3.77 ± 0.06 [c]	3.79 ± 0.07 [c]	3.75 ± 0.02 [c]	3.68 ± 0.04 [c]
	Cohesiveness (kgf)				
Lot I	0.33 ± 0.04 [a]	0.25 ± 0.03 [a]	0.24 ± 0.01 [a]	0.24 ± 0.02 [a]	0.22 ± 0.03 [a]
Lot II	0.35 ± 0.03 [a]	0.33 ± 0.02 [b]	0.33 ± 0.02 [b]	0.34 ± 0.03 [a]	0.34 ± 0.01 [a]
Lot III	0.37 ± 0.05 [a]	0.35 ± 0.02 [b]	0.34 ± 0.02 [b]	0.31 ± 0.05 [b]	0.31 ± 0.03 [b]
	Springiness (cm)				
Lot I	0.30 ± 0.01 [a]	0.22 ± 0.01 [a]	0.22 ± 0.01 [a]	0.22 ± 0.01 [a]	0.21 ± 0.01 [a]
Lot II	0.34 ± 0.03 [b]	0.28 ± 0.03 [b]	0.28 ± 0.03 [b]	0.28 ± 0.03 [b]	0.26 ± 0.03 [b]
Lot III	0.34 ± 0.01 [b]	0.28 ± 0.01 [b]	0.26 ± 0.01 [b]	0.25 ± 0.01 [b]	0.25 ± 0.01 [b]
	Fracture Force (N)				
Lot I	4.86 ± 0.04 [a]	4.89 ± 0.05 [a]	4.75 ± 0.04 [a]	4.72 ± 0.04 [a]	4.69 ± 0.04 [a]
Lot II	4.75 ± 0.04 [b]	4.95 ± 0.04 [a]	4.95 ± 0.04 [b]	4.98 ± 0.04 [b]	4.98 ± 0.04 [b]
Lot III	4.78 ± 0.03 [b]	4.70 ± 0.03 [b]	4.70 ± 0.03 [a]	4.70 ± 0.03 [a]	4.68 ± 0.03 [a]

Different superscripts in the same column indicate significant differences ($p < 0.05$).

based batter gave more luminosity to the coated product as it helped to retain moisture and to absorb less oil than the other two gums. Carboxy Methyl Cellulose and Carboxy Methyl Chitosan incorporated samples retained the crispness during frozen storage. On sensory evaluation, Carboxy Methyl Cellulose incorporated samples were found to have a better overall acceptability. The total bacterial load was in the intermediate count level for all the three products throughout the period of storage. From this study, it was observed that Carboxy Methyl Cellulose based batter system provided superior sensory qualities, maximum moisture retention capacity and minimum fat uptake to the coated shrimp.

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