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Effect of Hydrocolloids on the Functional Properties of Batter Mix Used for the Preparation of Coated Shrimps

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In the present study, the effect of the addition of three different hydrocolloids viz. Guar Gum (GG), Carboxy Methyl Cellulose (CMC) and Carboxy Methyl Chitosan (CMT) on the functional properties of batter mix used for the preparation of coated shrimps was investigated. The maximum viscosity was noticed in batter containing GG at 1:2 dilution followed by batters containing CMC and CMT. Among the three batter systems, GG based batter showed highest shear thinning behavior and indicated maximum viscosity at lower dilutions and lower shear rates. Compared to the other two batters, GG based batter indicated maximum water retention capacity irrespective of temperatures and dilutions. In coated shrimps, the highest pick up was observed with GG-based batter, followed by CMC and CMT based batters. Thus, in terms of functional properties and batter consistency, GG based batter mix was found to be superior to the other two batter mixes.

Key words: **Hydrocolloids, batter mix, coated shrimp, guar gum, carboxy methyl cellulose, carboxy methyl chitosan, viscosity, pick up.**

Ingredients serve numerous important functions in batters and breadings to give coatings their unique characteristics and functionalities. Important ingredients used in the manufacture of coatings are wheat flour, farinaceous material, corn flour, starch, modified derivatives of cellulose and gums, seasonings, etc. In the coated food, batter plays an important role in the final coating characteristics such as texture, color, flavour, moisture retention, oil absorption etc.

Among the constituents in the batter systems, hydrocolloids have a special role to play and hence they are widely used in the formulation of batters. Gums and starches are the most important types of hydrocolloids (Meyers, 1992). Hydrocolloids can be categorized according to origin, functional use, isolation or derivation methods and the presence of ionic charges (Whistler, 1973). Gums are used in food primarily as thickeners and gelling agents as a result of their ability to alter the rheological properties of the solvent in which they are dissolved (Yaseen *et al.*, 2005).

The primary use of hydrocolloids in batter formulation has been based on their capacity to immobilize water, and therefore, on their effect on viscosity. However the gel forming capacity of certain hydrocolloids such as Methyl Cellulose (MC) and Hydroxyl Propyl Methyl Cellulose (HPMC) has also been used with the aim of reducing the oil absorbed by the batter coated products during the frying process (Stypula and Buckholz, 1989; Meyers and Conklin, 1990; Chalupa and Sanderson, 1994).

Viscosity, solid suspension set-up character, leavening stability, moisture retention and flavor are the important batter selection characteristics. The use of ingredients that do not develop much viscosity, such as rice flour, make it necessary to incorporate a gum to ensure a quality similar to a classic formulation (Mukprasirt *et al.*, 2000). Since these rheological properties affect quantity and quality of batter pick up, appearance, color, texture and handling property of coated product, use of different hydrocolloids in the formulation of batter constitute an important element of quality determination in the commercial production of coated products. Improvements in shelf life and eating quality have been observed in fried products containing hydrocolloids in both substrate and coating system (Harris and Lee, 1974; Anon. 1980; Baker and Scott-Kline, 1988; D' Amico *et al.*, 1988).

Cellulosic gums do not add calories to batters (since they are essentially non digestible), the caloric reduction in the batter may help to reduce the caloric gain from the frying oil. This coupled with the oil barrier properties of the gums is useful in formulating batters that have both lower caloric and lower cholesterol levels. The most recent application of gums to batter coated products is to use the thermo gelling property of MC to create a new industrial manufacturing process for frozen batter coated foods which eliminates the pre frying stage and thus provides a healthier and more environment friendly alternative (Sanz *et al.*, 2004).

The main aim of this work was to study the effect of the addition of three different hydrocolloids viz., Guar Gum, Carboxy Methyl Cellulose and Carboxy Methyl Chitosan on the functional properties of batter mix used for the preparation of coated shrimps.

Materials and Methods

Preparation of dry batter mix

The ingredients used for the preparation of batter mix are given in Table 1. Food grade quality ingredients were used. The ingredients were mixed thoroughly using Tecator Homogenizer (Model Euro - turrax-T25b (IKA LABORTECHNIK) for two minutes. Different batter samples were prepared by adding three different hydrocolloids viz., Guar gum (GG), Carboxy Methyl Cellulose (CMC) and Carboxy Methyl Chitosan (CMT). The batter samples were packed in polyethylene pouches after cooling and stored in a cool, dry place for subsequent use.

Table 1. Ingredients of batter mix

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

* The typical level for the use hydrocolloid in batter systems is 0.5 -1% range (w/w, flour basis). Here a level of 0.96% was selected considering the optimum coating pick up of the product.

Preparation of breadcrumbs

The breadcrumbs used for coating was prepared from locally available sliced bread. After removing the crust portion using a sharp knife, the loaves were blended in an electric blender for one minute and the blended bread powder was dried in aluminum trays in an air oven maintained at 102 °C to a moisture level below 5%. The dried crumbs were then sieved to a uniform particle size and stored in a cool, dry place in polyethylene pouches.

Preparation of coated shrimp for batter pick–up studies

The batters containing three different hydrocolloids, GG, CMC and CMT were prepared with water in the ratio of 1:2 (W/V) using a Hobart Mixer (Model No.A 120, M/s Hobart Engineering Co. Ltd, UK) for 2minutes. Immediately after preparation of batter, the frozen Peeled & Deveined (PD) shrimps (species: *Fenneropenaeus indicus*) were weighed, pre-dusted using the same dry batter mix which was used for the preparation of the liquid batter and battered manually. The battered prawns were then coated with breadcrumbs and again weighed.

The amount of coating that adhered to the finished product was expressed as percentage of the total weight of the finished product (ie, pick up of coating) which was calculated using the formula:

$$\text{Pick up \%} = \frac{(\text{Coated weight} - \text{raw weight})}{\text{Coated weight}} \times 100$$

Rheological studies of batter

Flow properties

The viscosities of different batters were studied using Brookfield DV-E (Model-

LVDVE 230) viscometer equipped with LV-3 spindle. Apparent viscosity was measured as a function of shear rate over the range 10 to 100 s^{-1} at the following dilution ratios of Batter mix: water ie., 1:2, 1:2.5, 1:3, 1:3.5.

Water retention capacity

In order to evaluate the water retention capacity (WRC) of the different batter formulations, the amount of water released after centrifugation was quantified. 25g each of the liquid batter samples were centrifuged at 10,000 rpm for 10 minutes at three different temperatures viz., 10, 15 and 25°C in a Remi Cooling Compufuge (Model CPR-30). After centrifugation the supernatant was removed and weighed. Water retention capacity is expressed as the percentage of water released after centrifugation.

Statistical Analysis

Results expressed as mean ± SD of triplicate analyses. Statistical analysis between the means using ANOVA and Dunkens' multiple test were carried out to test the significance of variance. Statistical package used in the study is SPSS, 10.

Results and Discussion

Effect of Hydrocolloids on rheology of batter systems

Batter viscosity

The viscosity of a batter is the key characteristic for the quality of coating that it provides. It is also recognized as one of the most important factors in determining its performance during frying (Shih and Daygle, 1999). The most common use of gums is for batter viscosity adjustment (Davis, 1983). The effect of dilution on viscosity of three different batters containing three different hydrocolloids at a is given in Figure 1. The temperature of the batters were maintained at 25 °C. The maximum viscosity was noticed in batter containing GG at 1:2 dilution followed by batters containing CMC and CMT. There was a sharp decrease in the viscosity of batter containing GG from 4700 centipoises (cP) to 800 (cP) when the dilution was increased from 1:2 to 1:2.5 and thereafter the value showed a gradual decrease for further dilutions and at 1:3.5 dilution the value was 208 (cP). In the case of batter containing CMC the viscosity was 1700 (cP) at 1:2 dilution and on further dilutions a gradual decrease was noticed and at 1:3.5 dilution it was 45 (cP). Among the three batters the minimum viscosity was observed in the case of batter containing CMT. At 1: 3.5 dilutions the values for viscosity for batters containing CMC and CMT were almost same. In general, as dilution increased viscosity decreased. In the case of GG batter the reduction is more rapid. Batter viscosity influences the quantity and quality of pick-up, the potential for voids, the handling ease, breading pick-up and the final coating texture. It is itself affected by batter temperature, ingredient composition and the solid-water ratio (Sudermann, 1983).

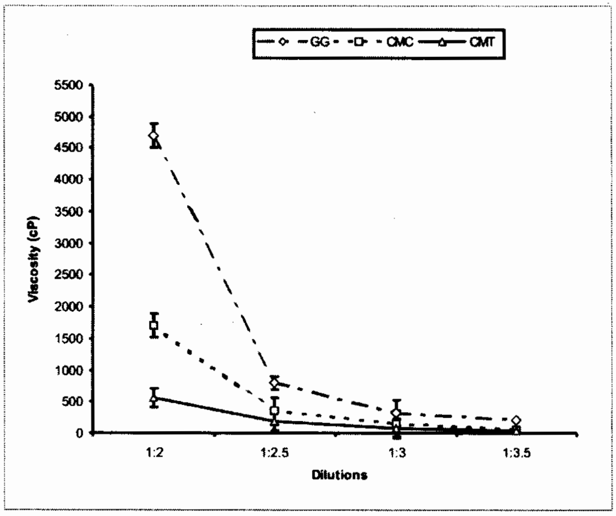

Fig. 1. Effect of dilution on viscosity of batter systems containing different hydrocolloids at 25°C.

Effect of shear on batter viscosity

The effect of shear rate on viscosity of different batters containing three different hydrocolloids at 1:2 dilution and at 25° C is given in Fig. 2. In general, batter viscosity decreases as shear increases. This shows that all three batters are non Newtonian and they have shear thinning behavior. Among the three, GG based batter showed highest shear thinning behavior. Also batter viscosity greatly depends upon the molecular weight. At lower dilutions and lower shear rates GG based batter indicated maximum viscosity because of its highest molecular weight. MC, HPMC& CMC based batters generally present shear thinning behavior, time dependency and thixotropy, so a rheological characterization of their behavior over a range of shear stresses and time gives more complete information for optimizing the process of mixing, pumping and coating, with a view to keeping the batter properties, pickup and adhesion uniform (Fiszman and Salvador, 2003)

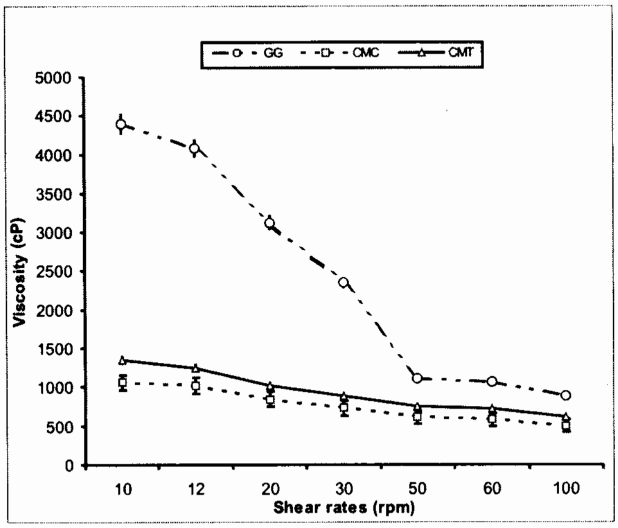

Fig. 2. Effect of hydrocolloids on batter viscosity (1:2 dilution, 25 ^{0} C) at different shear rates.

Water retention capacity

The effect of batter dilution and temperature on the water retention capacity (WRC) of the batters are shown in Figs. 3a, 3b and 3c. Compared to the other two batters, GG based batter indicated maximum water retention capacity irrespective of temperature and dilutions. The WRC of GG based batter was 100% at 1:2 dilution irrespective of temperature. The WRC of CMC and CMT based batters in the same dilution did not differ significantly at the same dilution but the values were significantly lower than that of GG based batter. At 1:2 dilution temperature does not have any influence on the WRC of GG based batter whereas in the case of CMC and CMT based batters a slight decrease was observed. At 1:2.5 dilution, WRC of GG based batter was 100% at 10 ^{0} C and 15 ^{0} C and a marginal decrease was observed at 25 ^{0} C. For CMC and CMT based batters the WRC was lower at 1:2.5 dilution

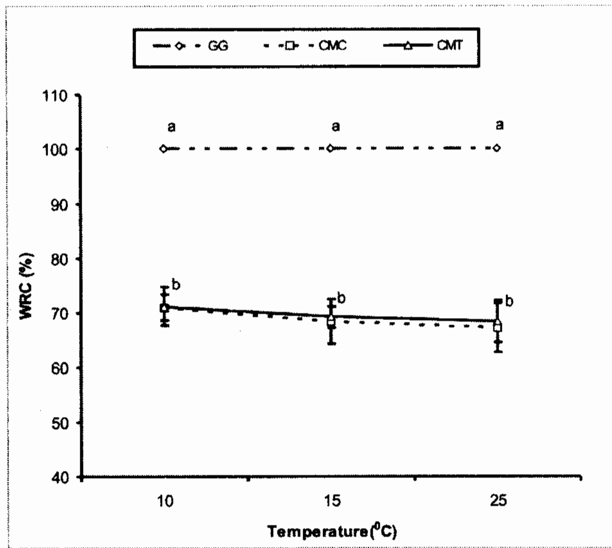

Fig.3a. Effect of temperature on water retention capacity of batters containing different hydrocolloids (1:2 dilution)

Different superscripts in the same X axis value indicate significant differences ($P < 0.05$).

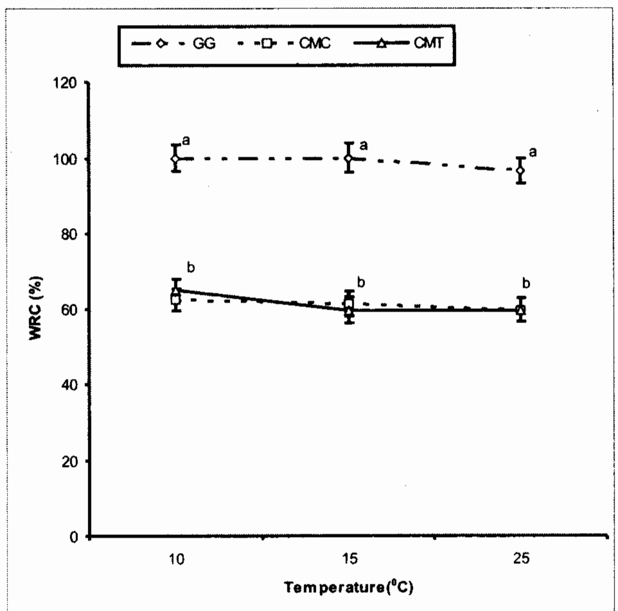

Fig. 3b. Effect of temperature on water retention capacity of batters containing different hydrocolloids (1:2.5 dilution)

Different superscripts in the same X axis value indicate significant differences ($P < 0.05$).

than at 1:2 dilution: however, there was no significant change in the WRC at 1:2.5 dilution at different temperatures. The WRC of GG based batter was significantly higher than the other two batters at 1:2.5 dilution. At 1:3 dilution, the WRC of the batter mixes

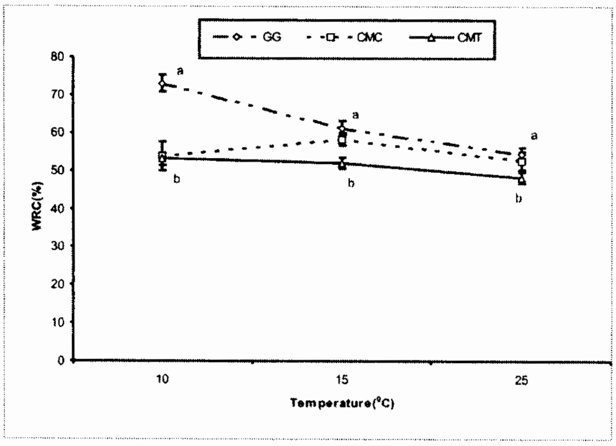

Fig. 3c. Effect of temperature on water retention capacity of batters containing different hydrocolloids (1:3 dilution)

Different superscripts in the same X axis value indicate significant differences ($P < 0.05$).

showed lower values than in other dilutions. The WRC of GG based batter showed a sharp decrease from 73% at 10 °C to 54.4% 25 °C. CMC batter showed an increase in WRC from 53.8% at 10 °C to 58.21% at 15 °C and decreased to 52.6% at 25 °C. At 15 °C and 25 °C there was no significant difference in the WRC of GG and CMC based batter at 1:3 dilution. CMT based batter showed the lowest WRC at 1:3 dilution and there was no significant change in the WRC at different temperatures. An increase in temperature resulted in lower consistency in several batter formulations (Baixauli *et al.*, 2003; Salvador *et al.*, 2003). The high water retention capacity of guar gum is due to its higher hydrophilic nature.

Final coating pick up

The coating pick up is an important physical property since it affects quality parameters of fried foods. The pick up measurements obtained with different hydrocolloid containing batters at 1:2 dilution are presented in Fig. 4. The highest pick up (40%) was found in the case of GG-based batter, followed by CMC (34%) and CMT (32%). The same trend was observed for all the three hydrocolloid based batters after pre frying. Coating pick up is directly related to batter viscosity ie., as viscosity increases more batter remains on the sample (Altunakar 2003; Dogan 2004). The viscosity of the batter systems affects the pick up and quality of the batter that adheres, the handling properties of the battered product, its appearance and its final texture (Fiszman & Salvadore, 2003). Gums are able to provide high viscosity to their dispersions even at low concentrations. Here GG based batter indicated highest viscosity because of its higher hydrophilic nature.

The present study gives an indication of the comparative effectiveness of the incorporation of three hydrocolloids in batter formulations with reference to their functional properties. The maximum viscosity was noticed in batter containing GG at 1:2 dilution followed by batters containing CMC and CMT. Among the three batter systems, GG based batter showed highest shear thinning behavior and indicated maximum viscosity at lower dilutions and lower shear rates. Compared to the other two batters, GG based batter indicated maximum water retention capacity irrespective of temperatures and dilutions. In breaded shrimps, the highest pick up was observed with GG-based batter, followed by CMC and CMT based batters. Thus in terms of functional properties and batter consistency, GG based batter mix was found to be superior to the other two batter mixes.

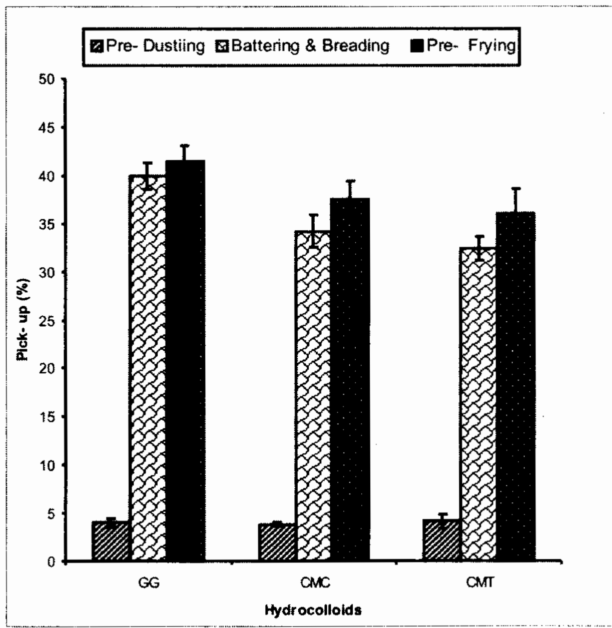

Fig. 4. Effect of hydrocolloids on pick up at different stages of coating (based on PD prawns)

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