Effect of Crude Malva Nut Gum and Phosphate on Yield, Texture, Color, and Microstructure of Emulsified Chicken Meat Batter

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ABSTRACT The effect of crude malva nut gum (CMG) use (0.0, 0.2, 0.6%) and sodium tripolyphosphate (TPP) addition (0.0, 0.5%) on the cook loss, texture, color, and microstructure of mechanically deboned chicken meat batters was studied. Increasing the level of CMG (a gum currently not used by the meat industry) in batters without TPP significantly increased yield. The batters with both CMG and TPP showed lower cook and fat losses compared with batters with CMG alone. Using 0.2 or 0.6% CMG and 0.5% TPP provided higher hardness values compared with using 0.6% CMG alone. The batter with 0.5% TPP and the batters with both CMG and TPP showed higher springiness compared with batters with CMG alone. Increasing the CMG level to 0.6% reduced the lightness and redness of the cooked products. Overall, the study demonstrated the beneficial effect of using CMG and TPP in improving the yield, stability, and texture of emulsified meat batters.

Key words: malva nut gum, meat batter, mechanically deboned chicken meat, Scaphium scaphigerum

INTRODUCTION

Comminuted meat batters are made by forming a dispersion of muscle proteins, fat, water, and salt. Heating the meat batter transforms the highly viscous dispersion into a protein gel filled with fat globules, which gives the meat product its characteristic texture (Giese, 1992). The stabilization of fat and water within the system is important in terms of yield and sensory acceptability (Gordon and Barbut, 1992). In meat batters, fat globules constitute the dispersed phase (Swasdee et al., 1982) but are sometimes larger than 20 μm, the size required to form a true emulsion (Lee, 1985). Mechanically deboned chicken meat (MDCM) is commonly used in the formulation of comminuted products because of its consistency and fairly low cost. It has good nutritional and functional properties and is suitable for different meat products (Dhillon and Maurer, 1975; Froning, 1981; Jones, 1986). Gums and nonmeat proteins are commonly used, with salt, to increase binding and improve the yield of meat products prepared with MDCM (Comer and Allan-Wojtas, 1988). The addition of gums such as xanthan, carrageenan, locust bean gum, and methylcellulose to meat products has been reported (Wallingford and Labuza, 1983; Foegeding and Ramsey, 1986; Mittal and Barbut, 1993). Guar gum was reported to bind free moisture and to retard shrinkage during cooking when used at 0.2 to 0.5%, whereas locust bean gum could impart a smooth texture in restructured meats and in sausages such as bologna (Dziezak, 1991). However, not all gums are compatible with meat batters. For example, xanthan gum significantly reduced hardness even though it did not affect meat batter stability (Whiting, 1984; Foegeding and Ramsey, 1986). Lin et al. (1988) found that adding carboxymethyl cellulose to low-fat, high-added-water frankfurters decreased the textural parameters, with the exception of springiness and cohesiveness. Mittal and Barbut (1993) reported lower springiness in low-fat pork breakfast sausages made with carboxymethyl cellulose. Barbut and Mittal (1992) reported that xanthan gum was detrimental to the textural and sensory properties of pork breakfast sausages.

Malva nut gum is a hydrocolloid extracted from the malva nut [Scaphium scaphigerum (G. Don) Guib and Planch]. The malva fruit has been used for centuries in South Asia as an herbal medicine for the relief of coughs and canker sores, but is currently not on the GRAS (Generally Recognized as Safe) list in North America. In previous experiments, the rheological properties of the isolated gum indicated the ability to bind water and to thicken or gel. Furthermore, in lean chicken meat batters, it showed potential as a meat extender, with 0.2% of the crude gum improving yield and textural properties (Somboonpanyakul et al., 2006, 2007). The objective of this study was to evaluate the effects of crude malva nut gum (CMG) and sodium tripolyphosphate (TPP) addition on the cook loss, fat loss, textural properties, color, and microstructure of
commercial-type emulsified meat batters prepared with MDCM.

**MATERIALS AND METHODS**

**Preparation of CMG**

Crude malva nut gum was extracted by soaking the nuts in water (1:80, wt/vol) at pH 7 for 15 h at 20°C. Excessive water was removed by filtering through a 40-mesh screen. The leftover fibrous debris was removed by a pneumatic press. The crude mucilage was precipitated with 3 vol of 95% ethanol and freeze-dried (Heto Drywiner DW.8-85, Heto-Holten A/S, Allerød, Denmark). The precipitate was then sieved through a 50-mesh screen. Proximate analyses of the CMG were determined in triplicate (AOAC, 1996). Average carbohydrate, ash, moisture, protein, and fat contents were 86.62, 5.87, 5.34, 2.17, and 0.00%, respectively.

**Preparation of Meat Batters**

The MDCM (16.99% protein and 10.24% fat; AOAC, 1996) was obtained from a local Ontario processing plant, and beef fat (8.20% protein and 70.90% fat) was obtained from the University of Guelph abattoir. The MDCM was kept frozen for up to 2 wk at −20°C prior to use. The beef fat was ground through a 9-mm plate to obtain a homogeneous mass prior to use. Six different MDCM batter formulations were prepared (Table 1) in 3 separate trials. For each treatment, 750 g of MDCM was thawed overnight at 4°C. The MDCM was chopped (Mainca model J908110, Equipomentos Carnicos, S.L., Barcelona, Spain) at low speed for 30 s followed by addition of 1.5% salt (based on meat weight) and 0.22% curing salt, which contained 0.064% sodium nitrite (control treatment formulation, treatment 1; Table 1), while chopping at the high speed setting for 30 s. In the TPP treatments, 0.5% TPP was also added at this point (i.e., a fairly standard formulation used by the meat industry). This was followed by a 1.5-min break (allowing time for protein extraction). Next, 23% beef fat was added and chopped at high speed for 1 min, followed by addition of 20% ice while chopping at high speed for 1 min. In the CMG treatments, the gum powder was mixed and added with the ice. The batters were chopped for an additional 2 min; batter temperature did not exceed 12°C in any of the treatments. The batters were vacuum-packed (Multivac D-8941, Multivac GmbH, Wolfertschwenden, Germany) to remove air pockets, and three 30-g batters were later stuffed into polypropylene tubes, which were centrifuged (Model 225, Fisher Scientific, Pittsburgh, PA) at the slow speed setting to remove trapped air. The batters were cooked in a water bath (Haake W-26, Haake, Berlin, Germany) from 10 to 75°C within 1.5 h.

**Cook Loss**

Fluid separated from the batters was measured after cooling for 15 min at 20°C and expressed as the ratio of liquid expelled to raw batter weight. The fat was then allowed to solidify in a 5°C cooler, after which it was skimmed and its amount determined.

**Texture**

A texture profile analysis (Bourne, 1978) was used to evaluate the cooked products. The center cores of 9 cooked samples (1.0 cm high, 1.5 cm in diameter) per treatment were compressed (Model TA.XT2, Stable Microsystems, Texture Technologies Corp., Scarsdale, NY) twice to 75% of their original height. Hardness, springiness, cohesiveness, and chewiness were determined.

**Color**

The color of the cooked batter was measured (Chroma Meter, Minolta, Co., Ltd., Model CR-200, Osaka, Japan) and expressed as Hunter L* (lightness), a* (redness), and b* (yellowness).

**Light Microscopy**

Small cooked sections (10 × 10 × 2 mm) were fixed in 10% neutral buffered formalin for 1.5 h, followed by
dehydrating in 70, 95, and 100% isopropanol each for 2 h. The samples were soaked in xylene for 2 h and embedded in paraffin for 3 h using an automated vacuum infiltration unit (Sakura Tissue-Tek VIP, Sakura Finetek, Torrance, CA). The embedded samples were sectioned (Microtome HM 200, Ergostar, Walldorf, Germany) into 4-μm sections, dried for 40 min, and stained with periodic acid Schiff’s reagent (Elbert, 1992). A computerized image analysis system attached to the microscope (Mode BX60F5, Olympus Optical Co., Ltd., Tokyo, Japan) was used to view (200× magnification) the samples and capture images.

Statistical Analysis

A 2 × 3 factorial experiment was conducted in 3 separate trials. The main effects were the presence or absence of 0.5% TPP at 3 different CMG levels (0, 0.2, 0.6%). Differences among treatment means were tested by Duncan’s multiple range test. The SAS software program, version 6.12, was used to perform the statistical analysis (SAS Institute, 1997).

RESULTS AND DISCUSSION

Cook and Fat Losses

The 0.2 and 0.6% CMG batters with 0.5% TPP (treatments 5 and 6; Table 1) and the batter with 0.5% TPP (treatment 4) showed lower cook losses compared with the batters with CMG alone (treatments 2 and 3) and the control. Based on previous work (Somboonpanyakul et al., 2007), we suggest that the mechanism by which CMG improves water holding is by binding and keeping the water in spaces within the protein gel network rather than by true interaction with proteins forming the network. Trius et al. (1994) investigated the effect of pork meat pH and TPP on the performance of carrageenans (κ, ι, and λ) in low-fat pork sausage model systems. Adding TPP or using high-pH meat (pH > 6.0) affected performance in a similar way, with both resulting in lower cook losses and firmer products. This was probably because TPP addition increased the pH of the meat batters, and when pH is high, meat proteins are more highly charged and repel each other, creating larger spaces for the water molecules. Increasing the level of CMG and adding TPP in this study also enhanced water holding of the meat batters (reducing cook loss).

In terms of fat losses, the presence of both CMG and TPP (treatments 5 and 6), resulted in lower fat losses compared with the batters with CMG alone (treatments 2 and 3). Schmidt (1984) indicated that fat loss from meat batters was mutually associated with an initial moisture loss during cooking. Hughes et al. (1997) also reported that addition of carrageenan or oat fiber reduced cook loss and increased both water holding and batter stability in pork-beef frankfurters. Addition of 0.5% TPP (treatment 4) resulted in a batter with lower fat loss (P < 0.05) compared with the control (treatment 1). This was because of the ability of TPP to extract more salt-soluble meat proteins from the meat and hence increase the stability of the batter. Whiting (1984) also reported that fat exudates from reduced-salt beef frankfurters (1.5% salt) were prevented by adding 0.12% pyrophosphate.

Texture

The batter with 0.6% CMG (treatment 3; Table 1) resulted in lower hardness compared with the control. This was probably due to the high amount of CMG that was distributed around the meat proteins, hindering their binding (resulting in lower gel strength). Similar findings were reported for 0.1 and 0.3% xanthan gum, which decreased the cooking losses and gel strength of low-salt beef frankfurters (Whiting, 1984). Montero et al. (2000) also reported that the presence of xanthan gum decreased the gel-forming ability of myofibrillar protein gels. They explained that the high molecular weight of xanthan gum probably hindered the formation of a protein network because the dry xanthan powder tended to aggregate and coil upon itself, thus occupying a large volume, which would distort the protein matrix. The batters with 0.2 or 0.6% CMG and 0.5% TPP (treatments 5 and 6) were harder than the batter with 0.6% CMG alone (treatment 3), but not the batter with 0.2% CMG (treatment 2). The added TPP apparently improved protein extraction but could not overcome the effect of 0.6% CMG distributed within the gel matrix. The batter with 0.5% TPP (treatment 4) and the batters with 0.2 or 0.6% CMG and 0.5% TPP (treatments 5 and 6) resulted in higher springiness compared with the batters with 0.2 or 0.6% CMG (treatments 2 and 3). This seems to be because TPP increased the pH of the meat and thus improved the water-holding capacity and springiness of the meat batters (Hamm, 1960).

Color

Increasing the CMG level to 0.6% decreased the lightness and redness of the MDCM batters (Table 1). The addition of CMG resulted in darker cooked batters. This was due to the proportionally higher amount of dark-colored CMG powder in the batters. The batter with 0.6% CMG (treatment 3) also resulted in lower yellowness when compared with the control (treatment 1) and the batter with 0.2% CMG (treatment 2).

Microstructure

The control (treatment 1, Figure 1A) showed a more open structure compared with the other treatments. The fat globules were evenly distributed within the meat batter and ranged from 20 to 100 μm. Gordon and Barbut (1990) observed similar stable meat batters and, by using high-magnification electron microscopy, concluded that stable fat globules usually exhibit some tiny, uniform pockets of exuding fat, whereas unstable batters show large fat exudates at weak points along the protein coats of the globule. In the present study, most fat globules
seemed to be very stable. Adding CMG at 0.2 and 0.6% (Figure 1B and 1C) provided denser matrixes compared with the control and visible CMG particles (see arrowheads), which showed the typical appearance of plant tissue. These denser matrixes could be the result of the lower cook losses in these treatments (compared with the control) or filling of the plant tissue particles. The batters with 0.2 or 0.6% CMG and 0.5% TPP (Figure 1E and 1F) showed a very dense matrix as well as some residual CMG particles distributed within the gel. This is presumably due to the better protein extraction by TPP, which further lowered cook loss (Table 1). The batter with 0.5% TPP alone (Figure 1D) showed a fairly dense protein matrix surrounding the fat globules but no plant tissue particles. Similar observations were reported by Schmidt (1984), who investigated the structural differences in the protein matrix of meat emulsions containing different levels of salt and TPP. He reported that the protein matrix of an emulsion with 0.58% salt had larger aggregates and larger capillary areas than emulsions with 2.82% salt or with 2.82% salt and 0.37% TPP.

In summary, adding 0.5% TPP to MDCM batters with 0.2 or 0.6% CMG was advantageous in improving the stability of the batters, as was evident in lower cook losses and according to light microscopy results. The batters with both CMG and TPP showed higher springiness compared with batters with CMG alone. Overall, the results demonstrated the beneficial effects of using CMG to im-

Figure 1. Light micrographs of comminuted batters: A) control; B) with 0.2% crude malva nut gum (CMG); C) with 0.6% CMG; D) with 0.5% sodium tripolyphosphate (TPP); E) with 0.2% CMG and 0.5% TPP; and F) with 0.6% CMG and 0.5% TPP. Arrowheads indicate CMG particles. Bar = 200 µm.
prove the yield, texture, and stability of emulsified meat batters.

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REFERENCES