Effect of malva nut gum (purified and crude), sodium chloride and phosphate on cooking, texture, colour, rheology and microstructure of different chicken meat batters

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Abstract
1. In the first experiment, the effect of adding purified malva nut gum (PMG) to comminuted poultry breast meat batters formulated with different contents of sodium chloride (NaCl; 10 to 30 g/kg) and tripolyphosphate (TPP; 0 and 5 g/kg) was studied.
2. Increasing salt (sodium chloride) content, along with the addition of 1 g/kg PMG, was beneficial in reducing cooking loss. At all salt contents, batters with PMG showed lower springiness than batters without PMG. Adding PMG to the batter with 20 g/kg salt and TPP decreased fracture force, springiness and chewiness.
3. In a second experiment, the effects of PMG (0, 3 and 6 g/kg), crude malva nut gum (CMG; 3 g/kg) and TPP (0 and 4 g/kg) on cooking loss, fat loss, colour, texture, rheology and microstructure of emulsified chicken meat batters were studied.
4. Increasing PMG reduced cooking and fat losses. Adding TPP increased hardness, springiness, cohesiveness and chewiness. The 1 g/kg PMG and TPP provided the greatest hardness. The batter with 3 g/kg PMG resulted in the lowest lightness (L*) and highest redness (a*). Adding PMG and TPP resulted in stable batters, as was evident by light microscopy results. The rheological evaluation showed the highest G’ in the batter with 4 g/kg TPP followed in decreasing order by the batters containing TPP plus 3 g/kg PMG, TPP plus 1 g/kg PMG, 3 g/kg PMG, 1 g/kg PMG, 3 g/kg CMG and the control.
5. Overall, the results are important for developing new applications where malva nut gum can be used to improve yield and stability of meat products.

INTRODUCTION

Hydrocolloid gums, used by the food industry, play an important role in enhancing structures, stabilising and improving functional properties of various products. Several researchers have reported on the applications of gums as meat binders, texture stabilisers and fat replacers (Trius and Sebranek, 1996). More specifically, Fox et al. (1983) reported that xanthan gum and carrageenan stabilised the texture of pickled frankfurters while guar gum, gum arabic and locust bean gum had no such effect. Trudso (1985) indicated that carrageenan improved water retention, consistency, sliceability and texture of poultry products especially with high levels of added brine. Foegeding and Ramsey (1986) reported that α-carrageenan, κ-carrageenan, guar gum, locust bean gum, xanthan gum and a κ-carrageenan/locust bean gum mixture could be used to prepare acceptable low-fat frankfurters. Bater et al. (1993) indicated that adding 5 g/kg κ-carrageenan to oven-roasted turkey breasts improved sliceability, rigidity and decreased expressible juice. Hsu and Chung (2001) indicated that using salt, κ-carrageenan and polyphosphates...
at 27.0, 20.0 and 1.7 g/kg, respectively, produced low-fat emulsified meatballs which were more acceptable, and showed higher cooking yields than a control with no added gum. Morin et al. (2004) indicated that β-glucan could hold more water in cooked sausages than carboxymethyl cellulose due to β-glucan ability to form a tighter network within the protein matrix. Bernal et al. (1987) suggested that protein and polysaccharide interactions are taking place due to the general electrostatic attraction between the negatively charged polysaccharides and positively charged proteins. Other interactions such as hydrogen, hydrophobic or covalent bonds may also affect the stabilisation of these complexes (Stainsby, 1980). Bernal et al. (1987) reported that a solution of beef myofibrillar proteins, with whey protein concentrated, formed stronger gels with polysaccharide gums than did a myofibrillar protein extract alone. They also reported that the electrostatic interactions seemed to be the main forces involved in the formation and stability of the gels. Thus, understanding the interactions between proteins and polysaccharides is important when polysaccharides are used to enhance the functional properties of food products (Ledward, 1979; Stainsby, 1980).

Malva nut is the seed of Scaphium scaphigerum (G. Don) Guib & Planch, which is used as a herbal medicine for relief of canker sores and cough in Thailand and other neighbouring countries. Somboonpanyakul et al. (2006) reported that the alkaline extracted malva nut gum is composed of 620.0 g/kg carbohydrate, 83.0 g/kg ash and 84.0 g/kg protein. The major carbohydrates are 319 g/kg arabinose, 292 g/kg galactose and 295 g/kg rhamnose. The gum also contains 64.0 g/kg uronic acid and small amounts of glucose, xylose and mannose. The molecular weight and intrinsic viscosity of the dialysed alkaline extract are 3.3 × 10^6 daltons and 7.70 ± 1.24 dl/g, respectively. The gum is not commonly used as a stabiliser or a thickening agent by the food industry. The main reason is believed to be the lack of reliable information on its functional properties and application in meat systems. In a previous study we have examined the potential use of a crude malva nut gum (CMG) in a chicken meat batter and reported that CMG improved the textural properties and cooking yield of the batters, particularly with 20 g/kg NaCl and phosphate (Somboonpanyakul et al., 2007). However, the functional properties and interactions between the pure gum extract and meat proteins have not yet been studied. Therefore, the objectives of this study were to investigate the effects of salt, purified malva nut gum (PMG), CMG and phosphate addition on very lean and fat added (emulsified) poultry meat batters. In addition the study was designed to gain a better understanding of the interactions between the gum and meat proteins.

MATERIALS AND METHODS

Preparation of purified malva nut gum (PMG)

Endogenous enzymes were inactivated by boiling the malva nut fruits in 80 ml absolute ethanol, adjusted to 100 ml with distilled water, for one hour. The gum extraction followed a general procedure described by Rombouts and Thibault (1986) with a few modifications. Briefly, the fruits were heated in water at 90°C for 2 h to extract the water-soluble fraction. Insoluble solids were separated by filtration through a silk-screen cloth, while the extract was centrifuged to discard the supernatant. The remaining solids, after water extraction, were extracted by 0.05 moles/l sodium hydroxide at 85°C for 30 min, and filtered through a silk-screen cloth. The extract was centrifuged and supernatant collected to yield the alkaline-soluble fraction. The pH of the alkaline-soluble extract was adjusted to 4.5 with 2 moles/l HCl. The alkaline-soluble fraction was further purified by dialysis against deionised water for 48 h at 22°C, using 3500 daltons molecular weight cut-off membrane (Spectra/Por® RC membrane, Spectrum Laboratories Inc., Rancho Dominguez, CA, USA). The purified gum was precipitated by adding three volumes of 95 ml ethanol adjusted to 100 ml with distilled water and washed with 100 ml absolute ethanol 3 times, followed by air-drying. Ash and moisture contents were determined according to the AOAC methods (1996). Protein content was determined from nitrogen content (N × 6.25) using an Automated Element Analyser (ThermoQuest Italia SpA, EA/NA 1110, Strada Rivoltana, Milan, Italy). Total carbohydrate was determined according to the method of Dubois et al. (1956). Average total carbohydrate, ash, moisture, protein and fat were 755 ± 1.4, 83 ± 0.5, 78 ± 1.2, 84 ± 0.5 and 0.0 g/kg, respectively.

Preparation of crude malva nut gum (CMG)

CMG was extracted by soaking the nuts in water (1:80 w/v) at pH 7 for 15 h at room temperature to completely hydrate and swell the fruit. Excessive water was then removed by filtering through a 40-mesh screen. The leftover fibrous debris was removed by a pneumatic press. The crude mucilage was precipitated with 5 volumes of 95 ml ethanol, adjusted to 100 ml with distilled water and freeze dried (Heto Drywinner DW 8-85, Heto-Holten A/S, Allerød, Denmark). The precipitate was then sieved through a 50-mesh screen. Proximate analyses of the
crude gum were determined in triplicate (AOAC, 1996). Average carbohydrate, ash, moisture, protein and fat contents were 866±2±2.5, 58.7±0.7, 53.4±1.5, 21.7±0.5 and 0.0 g/kg, respectively.

**Experiment I**

*Preparation of lean meat batters*

Lean chicken breast meat (12 kg) was obtained from an Ontario local processing plant and trimmed of all visible fat and connective tissue. The meat was chopped in a bowl chopper (SMK 40, Schneidmeister, Berlin, Germany) at the low speed setting for one minute (temp <8°C) to obtain a homogeneous mass. It was then vacuum packed in 500 g bags (Multivac D-8941, Multivac GmbH, Wolfertscherden, Germany) and kept frozen (−20°C) for up to 4 weeks prior to use. Proximate analyses of the raw meat were determined (AOAC, 1996) in duplicate. Average moisture, protein, fat and ash contents were 737±8, 224±6, 16±2 and 10±2 g/kg, respectively. The meat was thawed at 4°C for 24 h and 10 treatments were formulated with 100 g meat and 33 ml water. The dry ingredients of each treatment were as follows: Treatment 1 (0.0 g/kg salt, TPP and PMG), Treatment 2 (0.0 g/kg salt and TPP plus 1.0 g/kg PMG), Treatment 3 (10.0 g/kg salt, 0.0 g/kg TPP and PMG), Treatment 4 (10.0 g/kg salt, 0.0 g/kg TPP and 1.0 g/kg PMG), Treatment 5 (20.0 g/kg salt, 0.0 g/kg TPP and PMG), Treatment 6 (20.0 g/kg salt, 0.0 g/kg TPP and 1.0 g/kg PMG), Treatment 7 (30.0 g/kg salt, 0.0 g/kg TPP and PMG), Treatment 8 (30.0 g/kg salt, 0.0 g/kg TPP and 1.0 g/kg PMG), Treatment 9 (20.0 g/kg salt, 5.0 g/kg TPP and 0.0 g/kg PMG), Treatment 10 (20.0 g/kg salt, 5.0 g/kg TPP and 1.0 g/kg PMG). All treatments were mixed, by hand, for 3 min. All visible pieces of connective tissue were removed. The treatments were stored in a refrigerator for one hour to allow adequate equilibration. Later, three 30 g aliquots per treatment were placed into 50 ml polypyrrole centrifuge tubes and centrifuged (Model 225, Fisher Scientific, Pittsburgh, PA, USA) at the slow speed setting to remove all air bubbles. The chicken batters were cooked in a water bath (Haake W-26, Haake, Berlin, Germany) from 10 to 75°C within 1.5 h.

**Cooking loss**

Fluid separated from the batters was measured after cooling for 15 min at room temperature and expressed as % fluid loss from the raw meat batter.

**Texture profile analysis (TPA)**

TPA was determined using 9 cooked cores (each 1 cm high, 1.5 cm diameter) per treatment. The samples were compressed twice to 75% of their original height, using a texture analyser (TA-XT2, Texture Techniques Corp., Scarsdale, NY, USA). Hardness, springiness, cohesiveness, chewiness, fracture force and fracture distance were determined according to Bourne (1978).

**Statistical analysis**

The experiment was designed as a randomised complete block with 10 treatments in three independent trials. The treatments consisted of salt (0.0, 10.0, 20.0, 30.0 g/kg), PMG (0.0, 1.0 g/kg) and 5.0 g/kg sodium tripolyphosphate (TPP; Table 1).

Differences among treatment means were tested by Duncan’s multiple range test. SAS version 6.12 was used to perform the statistical analysis (SAS Institute, 1997).

**Experiment II**

*Preparation of emulsified meat batters*

Skinless chicken breast meat (221 g/kg protein and 16.9 g/kg fat) was obtained from a local Ontario processing plant. Pork back fat (729 g/kg fat and 54.7 g/kg protein) was obtained from the University of Guelph abattoir. The chicken was kept frozen for up to 2 weeks at −20°C prior to use. The pork back fat was cut into cubes (approx. 2 x 2 x 2 cm³) and kept in a freezer (−20°C) for 15 min before use. Seven different emulsified chicken batter formulations were prepared in three separate trials. The dry ingredients of each treatment were as follows: Treatment 1 (0.0 g/kg TPP and PMG), Treatment 2 (0.0 g/kg TPP and 1.0 g/kg PMG), Treatment 3 (0.0 g/kg TPP and 3.0 g/kg PMG), Treatment 4 (4.0 g/kg TPP and 1.0 g/kg PMG), Treatment 5 (4.0 g/kg TPP and 3.0 g/kg PMG) and Treatment 7 (3.0 g/kg CMG). For each treatment, 375 g of chicken meat was thawed overnight at 4°C. The meat was chopped (SMK 40, Schneidmeister) at low speed for 30 s followed by adding 7.5 g/kg salt (based on meat weight), 0.011 g/kg nitrite containing curing salt and 4.0 g/kg TPP, while chopping at the high speed setting for 30 s. This was followed by a 1.5 min break, to allow time for protein extraction. Next, 30% pork back fat was added and chopped at high speed for one minute, followed by adding 20% ice, while chopping at high speed for one minute. In the treatment with PMG, a gum solution was mixed and added with the ice. The batters were chopped for an additional 2 min; batter temperature did
Table 1. **Cooking loss and textural parameters of cooked lean chicken meat batters prepared with different levels of sodium chloride (salt), sodium tripolyphosphate (TPP) and purified malva nut gum (PMG); all batters were prepared with 33% added water**

<table>
<thead>
<tr>
<th>Treatment number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>Salt (g/kg)</td>
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<td>TPP (g/kg)</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
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<td>PMG (g/kg)</td>
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<td>1</td>
<td>0</td>
<td>1</td>
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<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cooking loss (%)</td>
<td>34.35±0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.49±0.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25.79±0.52&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.64±0.32&lt;sup&gt;d&lt;/sup&gt;</td>
<td>18.54±0.49&lt;sup&gt;e&lt;/sup&gt;</td>
<td>11.49±0.50&lt;sup&gt;f&lt;/sup&gt;</td>
<td>14.83±0.87&lt;sup&gt;g&lt;/sup&gt;</td>
<td>9.75±0.22&lt;sup&gt;h&lt;/sup&gt;</td>
<td>14.60±0.72&lt;sup&gt;i&lt;/sup&gt;</td>
<td>8.51±0.44&lt;sup&gt;j&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fracture force (N)</td>
<td>5.09±0.52&lt;sup&gt;ef&lt;/sup&gt;</td>
<td>3.04±0.30&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.98±0.50&lt;sup&gt;de&lt;/sup&gt;</td>
<td>4.63±0.41&lt;sup&gt;ef&lt;/sup&gt;</td>
<td>8.03±0.75&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>6.67±0.64&lt;sup&gt;de&lt;/sup&gt;</td>
<td>12.13±0.43&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>10.25±0.82&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>17.92±1.21&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.82±0.57&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fracture distance (mm)</td>
<td>3.60±0.02&lt;sup&gt;bcde&lt;/sup&gt;</td>
<td>3.44±0.05&lt;sup&gt;bcde&lt;/sup&gt;</td>
<td>3.34±0.05&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>3.36±0.01&lt;sup&gt;de&lt;/sup&gt;</td>
<td>3.66±0.02&lt;sup&gt;bcde&lt;/sup&gt;</td>
<td>3.54±0.03&lt;sup&gt;bcde&lt;/sup&gt;</td>
<td>4.26±0.10&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>3.90±0.22&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>4.96±0.55&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.18±0.22&lt;sup&gt;bc&lt;/sup&gt;</td>
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<tr>
<td>Springiness (mm)</td>
<td>0.34±0.02&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.26±0.01&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.41±0.02&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.36±0.03&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.48±0.01&lt;sup&gt;be&lt;/sup&gt;</td>
<td>0.43±0.04&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.61±0.02&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.52±0.01&lt;sup&gt;be&lt;/sup&gt;</td>
<td>0.71±0.02&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.61±0.04&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cohesiveness (ratio)</td>
<td>0.27±0.01&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.25±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.29±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
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<td>0.30±0.02&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.28±0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.34±0.02&lt;sup&gt;e&lt;/sup&gt;</td>
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<td>0.36±0.02&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.34±0.03&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chewiness (N mm)</td>
<td>2.93±0.32&lt;sup&gt;ef&lt;/sup&gt;</td>
<td>1.38±0.22&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.13±0.42&lt;sup&gt;de&lt;/sup&gt;</td>
<td>2.60±0.11&lt;sup&gt;ef&lt;/sup&gt;</td>
<td>4.88±0.54&lt;sup&gt;de&lt;/sup&gt;</td>
<td>3.50±0.12&lt;sup&gt;de&lt;/sup&gt;</td>
<td>8.02±0.41&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.85±0.29&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>10.63±0.55&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.25±0.45&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Hardness (N)</td>
<td>32.60±1.52&lt;sup&gt;bde&lt;/sup&gt;</td>
<td>20.91±1.02&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>36.19±1.55&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>25.98±1.21&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>34.25±1.15&lt;sup&gt;bde&lt;/sup&gt;</td>
<td>28.39±0.92&lt;sup&gt;bde&lt;/sup&gt;</td>
<td>41.10±1.86&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>35.83±0.72&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>41.80±0.85&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.96±1.85&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
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</table>

<sup>a</sup>Means (n = 9) within the same row and not sharing a common superscript are significantly different (P < 0.05).
not exceed 12°C in any of the treatments. The batters were vacuum packed (Multivac D-8941, Multivac GmbH) to remove air bubbles and later three 30 g batters were stuffed into 50 ml polypropylene centrifuge tubes, which were centrifuged (Model 225, Fisher Scientific) at the slow speed setting to remove trapped air. The batters were cooked in a water bath (Haake W-26, Haake) at 5-70°C within 1-5 h.

**Cooking and fat losses**

Determined as described in experiment I. Fat loss was determined as the amount of fat accumulating at the top of the test tubes after an overnight refrigeration period.

**Colour**

Colour of freshly cut cooked meat batter surfaces (9 pieces per treatment) was measured using a Spectra-colorimeter (Model MS/S-4500L, Hunter Associates Laboratory, Inc., Reston, VA, USA) and expressed as CIE L* (lightness), a* (redness) and b* (yellowness) values. The results are expressed as the average values from the three individual trials.

**Texture profile analysis (TPA)**

TPA was determined as described in experiment I.

**Rheological properties**

Continuous evaluations of the storage modulus (G’) during thermal processing of the meat batters were performed by a rheometer (Model CS 50, Bohlin Instruments Ltd, Cirencester, UK). Measurements were carried out using the cup and bob geometry (C25 DIN53019), frequency of 1 Hz and amplitude oscillation of 0-0012 strain units. A small amount of mineral oil was put on the top to prevent drying out during the cooking process. The chicken batters were heated from 30 to 70°C and cooled back down to 30°C at a rate of 1.5°C/min. Rheological data are presented as G’ value measured (Pa).

**Light microscopy**

Small cooked sections (10 x 10 x 2 mm³) from 6 treatments (1, 2, 3, 4, 5 and 6) were fixed in 10 ml formalin in 90 ml neutral buffer for 1-5 h, followed by dehydrating in 70 ml absolute isopropanol adjusted to 100 ml with distilled water for 2 h, 95 ml absolute isopropanol adjusted to 100 ml with distilled water for 2 h and 100 ml absolute isopropanol for 2 h. The dehydrated samples were soaked in xylene for 2 h and embedded in paraffin for 3 h. Sample preparation was done in an automated vacuum infiltration unit (Sakura Tissue-Tek VIP, Sakura Finetek, Torrance, CA, USA). The embedded samples were sectioned (Microtome HM 200, Ergostar, Walldorf, Germany) into 4 to 6 μm sections, dried for 40 min and stained with Periodic Acid Schiff’s reagent (Elbert, 1992). A computerised image analysis system attached to an Olympus microscope (Mode BX60F5, Olympus Optical Co., Tokyo, Japan) was used to view (x20 magnification) the samples and capture images.

**Statistical analysis**

The experiment was designed as a randomised complete block design with 7 treatments in three independent trials. The treatments consist of PMG (0, 1-0, 3-0 g/kg), CMG (0-0, 3-0 g/kg) with and without 4-0 g/kg phosphate (Table 2). Differences among treatment means were tested by Duncan’s multiple range test. SAS version 6.12 was used to perform the statistical analysis (SAS Institute, 1997).

**RESULTS AND DISCUSSION**

**Experiment I**

**Cooking loss from lean chicken batters**

Increasing the salt level from 0-0 to 30-0 g/kg significantly reduced cooking loss at every step (Table 1), as salt increases protein extraction and hence water-binding properties of chicken meat proteins. Overall, salt concentration had a significant effect on cooking loss. Schults and Wierbicki (1973) indicated that increasing salt from 0-0 to 10-0 g/kg reduced cooking loss of chicken meat from 35 to 18%, while using 20-0 or 50-0 g/kg salt resulted in 16% cooking loss. Gordon and Barbut (1992) reported that increasing NaCl from 15 to 25 g/kg resulted in greater protein extraction and different protein extraction profiles in chicken breast meat batters. When phosphate was added, cooking loss decreased significantly (P<0.05) from 18-54% (Treatment 5) to 14-60% (Treatment 9). Phosphate addition further assisted in extracting proteins, which enhanced moisture holding and binding among the small meat particles during heating. Several researchers have reported that some phosphates, in the presence of salt, show a synergistic effect in regard to increasing water-holding capacity of meat proteins (Schnell et al., 1970; Pepper and Schmidt, 1975; McMahon and Dawson, 1976; Neer and Madigo, 1977). Keeton (1983) reported that 10-0 g/kg NaCl plus 2-5 g/kg phosphate reduced cooking loss of pork patties. This implies that higher amounts of salt-soluble meat proteins were also extracted.
here as salt level was raised (10-0 to 30-0 g/kg) and later these extra proteins participated in network formation. Network formation improved with increasing salt level. Adding PMG further decreased (P<0.05) cooking loss (Treatments 2, 4 and 6 and Table 1). Overall, there was a significant effect of PMG on cooking loss. This was basically due to the ability of PMG to form a gel and retain water. Trudso (1985) reported that carrageenan improved water retention, consistency, sliceability and texture of poultry products prepared with high brine concentrations. Dev and Quensel (1989) also reported that the addition of 2-60% high mucilage protein concentrate and 3-34% low mucilage protein isolate (from linseed) to meat emulsions, reduced cooking loss by 45 and 49%, respectively. Dziezak (1991) reported that adding of 2 to 5 g/kg guar gum to sausages could bind free water and retard shrinkage, while locust bean gum addition provided stability and imparted a smooth texture in ground meat products such as salami and bologna. Barbut and Mittal (1996) indicated that cooked liquid loss was reduced from 10 to 6% when 3-5 g/kg carboxymethylcellulose was added to low-fat pork/beef frankfurters. Berry and Bigner (1996) reported that 15-0 g/kg salt with 3-8 g/kg κ-carrageenan improved cooking yield, juiciness and tenderness scores of partially cooked pork nuggets compared with all pork meat nuggets without the gum and salt. Treatment 10 showed the lowest cooking loss (8.51%) because, in addition to the 20-0 g/kg salt and 5-0 g/kg TPP, 1-0 g/kg PMG was also added, but it was not significantly different from Treatment 8. Trius and Sebranek (1996) reported that adding 5-0 g/kg TPP to pork sausages, formulated with or without carrageenan (κ, τ and λ), reduced cooking loss. The results reported here agree with a previous study by Somboonpanyakul et al. (2007) reporting that a chicken meat batter containing 20-0 g/kg salt, 5-0 g/kg TPP and 2-0 g/kg CMG had a low cooking loss compared to a control without the gum.

**Textural properties of lean chicken batters**

The treatment with 20-0 g/kg salt and 5-0 g/kg TPP showed the highest fracture force (17-92 N; Treatment 9; Table 1) because both salt and TPP extracted more proteins and improved binding. Increasing salt level from 10-0 to 30-0 g/kg significantly (P<0.05) increased springiness and chewiness but did not increase cohesiveness and hardness. Overall, the salt had a significant effect on fracture force and chewiness. Vadehra and Baker (1970) concluded that the binding between chunks of meat is a phenomenon involving structural rearrangement of the solubilised meat proteins. Maurer (1977) observed that 20-0 g/kg sodium chloride created a tightly bound poultry meat loaf product while the control treatment, with no salt, was loosely bound. The present study agrees with Barbut and Mittal (1989), who indicated that raw poultry meat batters became more rigid when a higher salt level is used, as more proteins are extracted. Adding 1-0 g/kg PMG to the batter significantly increased springiness and hardness but not cohesiveness and chewiness. Moreover, when 1-0 g/kg PMG was added to the batter with 20-0 g/kg salt and 5-0 g/kg TPP (Treatment 10), a significant reduction in fracture force was observed. That might be explained by some gum interference with the binding among meat particles.

### Table 2. Effect of purified maita nut gum (PMG), crude maita nut gum (CMG) and sodium tripolyphosphate (TPP) used in emulsified meat batters\(^*\) on cooking and fat losses, textural properties and colour (\(L^*\)=lightness, \(a^*\)=redness, \(b^*\)=yellowness)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
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<tr>
<td><strong>TPP (g/kg)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>0</td>
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<tr>
<td><strong>PMG (g/kg)</strong></td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
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<tr>
<td><strong>CMG (g/kg)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
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<tr>
<td><strong>Cooking loss (%)</strong></td>
<td>13-22(^a)</td>
<td>6-66(^b)</td>
<td>1-70(^d)</td>
<td>1-36(^de)</td>
<td>1-25(^de)</td>
<td>0-58(^e)</td>
<td>2-98(^c)</td>
</tr>
<tr>
<td><strong>Fat loss (%)</strong></td>
<td>0-67 ± 0-02(^a)</td>
<td>0-35 ± 0-01(^ab)</td>
<td>0-04 ± 0-01(^b)</td>
<td>0-01 ± 0-00(^b)</td>
<td>0-02 ± 0-00(^b)</td>
<td>0-01 ± 0-00(^b)</td>
<td>0-34 ± 0-01(^ab)</td>
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<tr>
<td><strong>Textural parameter</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Springiness (mm)</strong></td>
<td>0-37 ± 0-01(^f)</td>
<td>0-39 ± 0-05(^c)</td>
<td>0-35 ± 0-02(^b)</td>
<td>0-76 ± 0-04(^*)</td>
<td>0-68 ± 0-03(^a)</td>
<td>0-67 ± 0-01(^b)</td>
<td>0-33 ± 0-01(^f)</td>
</tr>
<tr>
<td><strong>Cohesiveness (ratio)</strong></td>
<td>0-16 ± 0-02(^b)</td>
<td>0-16 ± 0-02(^b)</td>
<td>0-16 ± 0-02(^b)</td>
<td>0-27 ± 0-01(^*)</td>
<td>0-27 ± 0-02(^a)</td>
<td>0-25 ± 0-01(^b)</td>
<td>0-17 ± 0-02(^b)</td>
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<tr>
<td><strong>Chewiness (N mm)</strong></td>
<td>1-06 ± 0-01(^e)</td>
<td>1-12 ± 0-12(^e)</td>
<td>0-93 ± 0-04(^d)</td>
<td>7-15 ± 0-55(^c)</td>
<td>6-82 ± 0-33(^a)</td>
<td>3-85 ± 0-11(^b)</td>
<td>0-85 ± 0-05(^f)</td>
</tr>
<tr>
<td><strong>Hardness (N)</strong></td>
<td>18-54 ± 0-59(^ab)</td>
<td>17-92 ± 0-24(^bc)</td>
<td>15-80 ± 0-25(^a)</td>
<td>34-51 ± 0-61(^a)</td>
<td>35-52 ± 0-79(^a)</td>
<td>24-94 ± 0-37(^a)</td>
<td>15-40 ± 0-35(^a)</td>
</tr>
<tr>
<td><strong>Colour ((L^<em>, a^</em>, b^*))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>(L^*)</strong></td>
<td>80-72 ± 0-04(^a)</td>
<td>77-39 ± 0-02(^b)</td>
<td>72-45 ± 0-05(^b)</td>
<td>80-60 ± 0-02(^a)</td>
<td>75-90 ± 0-04(^b)</td>
<td>70-28 ± 0-02(^d)</td>
<td>76-48 ± 0-01(^b)</td>
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<tr>
<td><strong>(a^*)</strong></td>
<td>1-41 ± 0-01(^d)</td>
<td>5-79 ± 0-02(^e)</td>
<td>5-92 ± 0-01(^d)</td>
<td>1-65 ± 0-01(^d)</td>
<td>5-44 ± 0-02(^a)</td>
<td>5-33 ± 0-07(^b)</td>
<td>3-61 ± 0-03(^f)</td>
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<tr>
<td><strong>(b^*)</strong></td>
<td>9-84 ± 0-02(^de)</td>
<td>10-46 ± 0-01(^b)</td>
<td>11-88 ± 0-02(^a)</td>
<td>9-52 ± 0-01(^d)</td>
<td>9-48 ± 0-02(^d)</td>
<td>10-59 ± 0-04(^b)</td>
<td>12-16 ± 0-05(^*)</td>
</tr>
</tbody>
</table>

\(^*\)Batters were composed of chicken meat, ice, pork back fat, sodium chloride, and sodium nitrite.

**Means (n = 9) within the same row and not sharing a common superscript are significantly different (P<0.05).**
However, Treatment 10 was not significantly different from Treatments 7 and 8. Foegeding and Ramsey (1986) reported that fat reduction (25 to 10%) and xanthan gum addition (0.5%) significantly affected hardness of low-fat meat batters. Mittal and Barbut (1994) also reported that hardness of low-fat pork/beef frankfurter was reduced by κ-carrageenan and xanthan gums. Trius et al. (1994) reported that the peak stress value of pork/beef bologna containing 20.0 g/kg salt and 5.0 g/kg λ-carrageenan was significantly lower than that of a control low-fat bologna (that is, 99 vs 131 kPa). Mittal and Barbut (1993) reported that hardness of low-fat pork/beef frankfurter was decreased by addition of 5.0 g/kg microcrystalline cellulose particles. A similar trend has been reported by Somboonpanyakul et al. (2007), who showed that fracture force of the chicken meat batter with 20.0 g/kg salt and 5.0 g/kg TPP was reduced by 2.0 g/kg CMG. Fracture distance, springiness and chewiness of the batter with 20.0 g/kg salt, 1.0 g/kg PMG and 5.0 g/kg TPP (Treatment 10) were also lower than the treatment without PMG (Treatment 9). Springiness values of treatments with PMG (Treatments 2, 4, 6 and 8; Table 1) were lower than the corresponding treatments without PMG (Treatments 1, 3, 5 and 7; Table 1). This might be explained by certain gums interfering with the binding of the meat particles, without influencing cooking loss of the batters. The low level of uronic acids (64.0 g/kg) in PMG may have resulted in a low anionic content of the gum (Somboonpanyakul et al., 2007). Thus, the resulting gel, formed between the positively charged meat proteins and PMG, would not be good enough to enhance binding among meat particles. Similar findings have been presented by Whiting (1984) who indicated that adding 1.0 or 3.0 g/kg xanthan gum decreased cooking losses but also gel strength of beef frankfurters. Moreover, Foegeding and Ramsey (1986) reported that increasing xanthan gum concentration (that is, an anionic gum), decreased beef/pork meat batter hardness, without affecting batter stability. Later, Mittal and Barbut (1993) reported that springiness of low-fat pork breakfast sausage was decreased by the high apparent viscosity of carboxymethylcellulose.

Experiment II

Cooking loss from emulsified chicken batters

Cooking losses between 13-22 and 0.58% were observed for the various treatments (Table 2). Overall, both PMG and TPP parameters had significant effects on cooking loss. Compared to the control, the addition of 1.0 and 3.0 g/kg PMG, or 3.0 g/kg CMG significantly decreased cooking losses from 13.22% to 6.66, 1.70 and 2.98%, respectively. This was most probably due to the ability of both PMG and CMG to form a gel that can retain water within the meat batters. Foegeding and Ramsey (1986) reported an increase in water-holding ability of low-fat beef Frankfurters when carrageenans were used. Barbut and Mittal (1996) found that cooking loss was reduced from 10 to 6%, when carboxymethylcellulose was added to low-fat pork/beef frankfurters. Hughes et al. (1997) reported that addition of carrageenan or oat fibre reduced cooking loss and increased water-holding capacity as well as batter stability. However, when compared here at the same level of malva nut gums (3.0 g/kg), the chicken batter with 3.0 g/kg PMG (Treatment 3) had lower cooking loss than the chicken batter with 3.0 g/kg CMG (Treatment 7). This was probably because PMG had uronic acid (64.0 g/kg) which was more effective in binding with the meat proteins than CMG. In the chicken batters with 4.0 g/kg TPP, increasing the level of PMG from 0.0 to 1.0 and 3.0 g/kg (Treatments 4, 5, 6) showed a trend of decreasing cooking loss. This might have been due to the combined effect of PMG and TPP, which helped to decrease cooking loss. It is possible that PMG could retain more moisture by itself, while TPP was attached to the positively charged groups of the meat proteins, and the other part of the TPP molecule attracted to other water molecules (Steinhauer, 1983). Similar results were reported by Trius et al. (1994) who found that adding 5.0 g/kg TPP to pork sausages, formulated with or without carrageenans (κ, τ and λ), increased hardness and reduced cooking losses. DeFreitas et al. (1997) found that adding carrageenans (κ, τ and λ) decreased thaw-drip of cooked sausages made either with or without phosphate. Hsu and Chung (2001) also reported that adding salt, polyphosphates and κ-carrageenan (27.0, 1.7 and 20.0 g/kg, respectively), produced low-fat emulsified meatballs that showed high cooking yields and were more acceptable.

Fat loss from emulsified chicken batters

The batters with PMG and TPP (Treatments 5 and 6; Table 2), with only 3.0 g/kg PMG (Treatment 3) and 4.0 g/kg TPP (Treatment 4) showed lower fat losses than the control (Treatment 1). These results were supported by the low cooking loss values discussed above and also in this case there was a significant gum effect. This is in agreement with Schmidt (1984) who indicated that fat loss from meat batters are always associated with initial moisture loss during cooking. The addition of 1.0 g/kg PMG
(Treatment 2) or 3.0 g/kg CMG (Treatment 7) did not affect fat loss of the batters.

**Textural properties of emulsified chicken batters**

Increasing PMG content from 1.0 to 3.0 g/kg without TPP addition, did not affect the textural parameters of the batters compared to the control. The batters with PMG and TPP (Treatments 5 and 6) showed higher springiness, cohesiveness, chewiness and hardness compared to the batters with only PMG (Treatments 2 and 3). This was due to the combined effect of PMG and TPP in increasing water-holding capacity and binding. The ability of phosphates to increase pH, enhance water-holding capacity, induce solubilisation of actomyosin and improve texture has been documented (Molins, 1991). Trius et al. (1994) reported that adding 5.0 g/kg TPP to pork sausages formulated with or without carrageenans (κ, τ and λ) increased hardness. DeFreitas et al. (1997) also reported that κ-carrageenan increased hardness of the pork sausages with or without phosphate when NaCl was used. However, the batter with 3.0 g/kg PMG and 4.0 g/kg TPP (Treatment 6) showed lower hardness, springiness and chewiness compared to the batter with only 4.0 g/kg TPP (Treatment 4). This might have been because the higher level of PMG interfered with some of the binding among meat particles and reduced these textural parameters. Similar findings have been shown by Foegeding and Ramsey (1986) when increasing xanthan from 0.1 to 5.0 g/kg which significantly reduced hardness of low-fat pork/beef emulsions without affecting emulsion stability. Mittal and Barbuts (1994) also indicated that low-fat pork/beef frankfurter’s hardness, springiness and chewiness values were reduced by κ-carrageenan and xanthan gum. The addition of 3.0 g/kg PMG (Treatment 3) or 34.0 g/kg CMG (Treatment 7) to the batters did not affect all textural parameters compared to the control (Treatment 1). Thus, it can be concluded that the addition of 3.0 g/kg PMG or 3.0 g/kg CMG alone, could not improve the textural properties of the chicken batters; however, the addition of TPP enhanced the textural properties of the batters.

**Colour of emulsified chicken batters**

The lightness (L*) of the batters without gum (Treatments 1 and 4; Table 2) were higher than the other batters. That was expected since the extracted gum powder had a pretty dark colour. Increasing PMG level from 1.0 to 3.0 g/kg, further reduced L* values. Redness (a*) and yellowness (b*) were increased by 3.0 g/kg PMG (Treatment 3) or 3.0 g/kg CMG (Treatment 7) compared to the control. This was again due to the dark-coloured PMG and CMG. Overall, the L* and a* values of the 3.0 g/kg PMG batter (Treatment 3) were significantly different compared to the values of the batter with 3.0 g/kg CMG (Treatment 7). Thus it can be concluded that the 3.0 g/kg PMG affected the colour of the batters more than 3.0 g/kg CMG.

**Rheological properties of emulsified chicken meat batters**

During heating the batters (30 to 70°C) with PMG and TPP (Treatments 5 and 6; Figure 1) and the batter with only 4.0 g/kg TPP (Treatment 4) there was a slight increase in G’ up to 55°C indicating that a stiff protein matrix was slowly developing. In the temperature range of 58 to 63°C, there was a rapid linear increase in G’, exhibiting a maximum value at 70°C. The transition at 55°C has been attributed to myosin and the one at 63°C to collagen and the sarcoplasmic protein denaturation (Wright et al., 1977). The decrease in G’ at 55°C (Treatments 1, 2, 3 and 7) and 57°C (Treatments 4, 5 and 6) might have been due to some fat melting (Acton et al., 1982). Wu et al. (1985) also studied transitions occurring during the gelation of meat batters, by using a thermal scanning rigidity monitor at a constant heating rate of 1°C/min. They reported three transition temperatures at 38, 46 and 60°C. The first transition was attributed to fat melting and the second and third to the formation of a stable network and a strong gel structure. Schweid and Toledo (1981) indicated transition points at 35 to 36 and 57 to 67°C. They suggested that these temperatures represent the points where insolubilisation and solubilisation of collagen occur, respectively. Saliba et al. (1987) reported that the major decrease in energy loss occurred in the 40 to 60°C range and that the major increase in modulus of rigidity, of beef frankfurter batters, started to show at 58°C. Foegeding and Ramsey (1987) followed the rigidity changes during heating of meat emulsions containing various carrageenan and xanthan gum combinations, and observed a slight variation in G’ values from 34 to 58°C, but major differences from 58 to 70°C due to the gums. The batters with PMG and TPP (Treatments 5 and 6) and with only 4.0 g/kg TPP (Treatment 4) showed higher rigidity than batters with PMG (Treatments 2 and 3), 3.0 g/kg CMG (Treatment 7) and the control (Treatment 1) throughout most of the cooking process (Figure 1). The batter with 4.0 g/kg TPP (Treatment 4) showed the highest G’ value at 70°C (8418 Pa; Table 3). It was higher than the batter with both 3.0 g/kg PMG and 4.0 g/kg TPP (Treatment 5), but not different from the batter with only 0.3% PMG (Treatment 3; 7884 Pa). Foegeding and Ramsey (1987)
there was a decrease in $G'_0$ from 30 to 55°C, followed by rapid $G'$ increase up to 70°C where they reached their maximum values. This indicates that they formed less stiff protein matrixes compared to batters with both PMG and TPP (Treatments 5 and 6) and with 4.0 g/kg TPP (Treatment 4). These treatments showed one transition temperature at 54 to 55°C. A change in the thermally induced rigidity transition at 54 to 55°C would implicate that malva nut gum–meat protein interactions affect matrix formation. The rapid increase in $G'$ starting at 58°C, observed in all 4 treatments, indicates myosin denaturation overcoming that interference. The general pattern observed here for the denaturation of the control batter (7.5 g/kg salt) is similar to the pattern previously reported for white poultry meat batters with 10.0 g/kg salt (Mittal and Barbut, 1989). The lowest $G'$ at 70°C was observed in the control (Treatment 1) and its $G'$ value did not significantly differ from the 3.0 g/kg CMG batter (Treatment 7; Table 3). Therefore, it can be concluded that adding 3.0 g/kg CMG did not contribute to the gel formation. It was the same for 1.0 g/kg PMG. These results agree with the TPA results (Table 2) showing no effect of CMG. Foegeding and Ramsey (1987) also reported that beef batters with xanthan gum exhibited lower rigidity during the entire heating process but xanthan did not affect the transition temperature at 58 to 60°C. They also explained that the mechanism by which xanthan gum interferes with rigidity could be related to its surface properties or an unknown role in the protein aggregation process. In the present study, the average $G'$ values (at 70°C) in increasing order were: Treatments 1, 7, 2, 5, 6, 3 and 4. This agrees with the TPA results (Table 2) showing that the batters with 1.0 g/kg PMG plus 4.0 g/kg TPP (Treatment 5) and with only 4.0 g/kg TPP (Treatment 4) produced higher textural parameter values compared to batters without TPP (Treatments 1, 2, 3 and 7).

### Light microscopy

The control batter (Treatment 1, Figure 2A), batter with 1.0 g/kg PMG (Treatment 2, Figure 2B) and batter with 3.0 g/kg PMG (Treatment 3, Figure 2C) showed less uniform fat distribution than the TPP-containing batters (Treatments 4, 5 and 6) and the fat was partly coalesced into larger fat globules. The control batter and the 1.0 g/kg PMG (Figures 2A and B) showed more coarse protein matrix structures compared to the 5.0 g/kg PMG batter (Figure 2D). Also, the fat globules within the control batter (Figure 2A) and the 1.0 g/kg PMG batter (Figure 2B) were larger and more elongated than in the 3.0 g/kg PMG batter (Figure 2C). Thus, the control (Figure 2A) and

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**Table 3. Storage modulus ($G'$) of emulsified chicken meat batters before cooking (30°C), after cooking (70°C) and after cooling to 30°C. Batters were prepared with different levels of purified malva nut gum (PMG), crude malva nut gum (CMG) and sodium tripolyphosphate (TPP)***

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Storage modulus ($G'$, Pa) (heating)</th>
<th>Storage modulus ($G'$, Pa) (cooling)</th>
</tr>
</thead>
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<tr>
<td></td>
<td>30°C</td>
<td>70°C</td>
</tr>
<tr>
<td>1</td>
<td>2290 ± 437.5 ± 5792 ± 338.8²</td>
<td>11 716 ± 1271.2²</td>
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<tr>
<td>2</td>
<td>2265 ± 427.2² 6204 ± 572.8²</td>
<td>13 775 ± 1864.6²</td>
</tr>
<tr>
<td>3</td>
<td>2208 ± 159.9² 7884 ± 572.8²</td>
<td>14 941 ± 864.7²</td>
</tr>
<tr>
<td>4</td>
<td>2933 ± 565.2² 8418 ± 402.0²</td>
<td>18 275 ± 2014.5²</td>
</tr>
<tr>
<td>5</td>
<td>2169 ± 465.2² 7035 ± 360.3²</td>
<td>18 916 ± 1074.4²</td>
</tr>
<tr>
<td>6</td>
<td>3490 ± 643.7² 7274 ± 160.7²</td>
<td>17 716 ± 1435.6²</td>
</tr>
<tr>
<td>7</td>
<td>1880 ± 256.5² 5814 ± 456.3²</td>
<td>12 866 ± 1530.0²</td>
</tr>
</tbody>
</table>

Meaning within the same column and not sharing a common superscript are significantly different ($P<0.05$).
1.0 g/kg PMG batter (Figure 2B) were less stable than the batter with 3.0 g/kg PMG (Figure 2C). This is in agreement with the cooking and fat loss results (Table 2), which indicated that adding 3.0 g/kg PMG resulted in lower cooking loss than the control batter. This is probably because the higher level of PMG helped bind liquid (reducing cooking and fat losses), thus improving batter stability. Koolmees et al. (1989) also indicated that the predominant way of fat stabilisation, in the absence of polyphosphate, was through physical entrapment of the larger fat particles in a coarser matrix. The reverse was observed for batters with PMG and TPP (Figures 2E and F) and batter with only 4.0 g/kg TPP (Figure 2D). All three batters showed a dense protein matrix and a large number of evenly distributed small fat globules. Most of the fat particles in the TPP-containing batters (Figures 2D, E and F) were more round, smaller and better distributed within the protein matrix than in batters without TPP (Treatments 1, 2 and 3), as can be seen in Figures 2D, E and F. Moreover, most of the fat particles in the 4.0 g/kg TPP batters were less coalesced than in the batters without TPP. This can be explained by the fact that TPP usually helps to reduce batter viscosity during chopping and also results in a higher meat protein extraction; that is, the later ultimately contributes to matrix formation and fat stabilisation. A similar finding was reported by Koolmees et al. (1989) indicating that polyphosphate addition, into beef emulsions, resulted in a dense protein matrix which was observed to stabilise numerous small fat droplets, even after extended chopping time of high-fat emulsions. In the present study, the PMG particles distributed in the protein matrix (arrowheads in Figures 2E and F), bound some

Figure 2. Light micrographs of emulsified chicken meat batters: (A) no sodium tripolyphosphate (TPP) and no purified malva nut gum (PMG) (Treatment 1), (B) no TPP and 1.0 g/kg PMG (Treatment 2), (C) no TPP and 3.0 g/kg PMG (Treatment 3), (D) 4.0 g/kg TPP and no PMG (Treatment 4), (E) 4.0 g/kg TPP and 1.0 g/kg PMG (Treatment 5), and (F) 4.0 g/kg TPP and 3.0 g/kg PMG (Treatment 6). The arrowheads indicate PMG particles. Bar = 200 μm.
of the water. This may have freed more meat proteins to form a firmer gel structure and hence improved stability of the batters. Comer and Allan-Wojtas (1988) also indicated that some common fillers used by the meat industry (for example, polysaccharides, gums, starches and non-meat proteins) are added because of their ability to bind moisture and/or fat in a gel structure during/after heating. Fillers added to a comminuted meat system are generally used to increase both fat stability and textural firmness. Gordon and Barbut (1990) observed that unstable batters contain fat globules that show large exudations, at weak points in their protein coats. However, stable emulsions show minimal exudation and often small uniform pockets of exuding fat which serve as a ‘pressure release’ mechanism during the heating and fat expansion phase. Unstable batters (that is, with large fat exudations) were shown to be more likely to form fat channels and facilitate coalescence (Gordon and Barbut, 1989).

Conclusions

The results indicate that increasing salt (sodium chloride) content, along with the addition of PMG, was beneficial in reducing cooking loss of lean chicken batters, particularly when TPP was added. Adding PMG to the batter with 20.0 g/kg salt and 5.0 g/kg TPP decreased fracture force, fracture distance, springiness and chewiness of the batter. This was most probably because PMG has a low ionic acid content and hence less negative charges to bind with the meat proteins. In the emulsified chicken meat batters, the addition of PMG and TPP was beneficial in enhancing binding among the finely chopped meat particles and improving cooking yield. The results from both the lean and fat added (emulsified) systems indicate the positive contribution of malva nut gum in improving meat batters. This information is important for developing new applications and/or optimising the use of malva nut gum in meat products.

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