Textural and sensory quality of poultry meat batter containing malva nut gum, salt and phosphate

Promluck Somboonpanyakul\textsuperscript{a}, Shai Barbut\textsuperscript{b,}\textsuperscript{*}, Pantipa Jantawat\textsuperscript{a}, Ninnart Chinprahast\textsuperscript{a}

\textsuperscript{a}Department of Food Technology, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand
\textsuperscript{b}Department of Food Science, University of Guelph, Ont., Canada N1G 2W1

Received 17 June 2005; received in revised form 10 November 2005; accepted 16 December 2005

Abstract

The effect of crude malva nut gum (CMG) addition to poultry breast meat batters formulated with different salt levels (0–3 g/100 g NaCl) and phosphate (0 and 0.5 g/100 g) was studied. Increasing the salt level resulted in an overall increase of cook yield, and the addition of CMG (0.2 g/100 g) further improved yield at all salt levels. The cooked batter with 2 g/100 g NaCl and phosphate showed the highest values for all of textural parameters. However, the cohesiveness and chewiness were reduced by the addition of 0.2 g/100 g CMG.

In addition, the effect of incorporating CMG (0.0, 0.2 and 0.6 g/100 g) into commercial type frankfurters, made from mechanically deboned chicken meat (MDCM), was evaluated. Frankfurters with 0.2 g/100 g CMG showed low cooking loss and had better textural properties than the frankfurters without CMG. Frankfurters lightness and redness were reduced due to CMG. Sensory analysis results indicated that the frankfurters with 0.2 g/100 g CMG were more firm and elastic. Overall, the study indicates the potential use of CMG to improve yield and textural parameters of meat products.

\textsuperscript{©} 2006 Swiss Society of Food Science and Technology. Published by Elsevier Ltd. All rights reserved.

Keywords: Frankfurters; Malva nut; Poultry meat batter; \textit{Scaphium scaphigerum} (G. Don) Guib & Planch

1. Introduction

Appropriate binding of minced meat and high water retention are two important factors in marketing high-quality processed meat products. The actual binding depends on factors such as the type of meat, salt concentration, temperature and pH of the meat. Binding of meat particles occurs during cooking as heat coagulation of the proteins is taking place. This can be measured as an increase in the shear force value during cooking (Asghar, Samejima, & Yasui, 1985; Gordon & Barbut, 1992; Saliba, Foegeding, & Hamann, 1987). On the other hand, water binding decreases, during cooking, due to protein denaturation (Schults & Wierbicki, 1973). Various nonmeat proteins and carbohydrates especially hydrocolloid gums, are often used to enhance the water binding and texture of meat products (Lanier, 1991). In general, they are added as another gelling system to improve yield, textural properties and also reduce cost of the meat formulation (Hung & Smith, 1993).

Malva nut fruit [\textit{Scaphium scaphigerum} (G. Don) Guib & Planch] is known in Thailand as Pungtarai or Sumrong. The plant belongs to the Sterculiaceae family which includes other species such as \textit{Scaphium macropodum} (Miq.) Beumee and \textit{Sterculia lycchnophora} Hance. \textit{S. scaphigerum} (G. Don) Guib & Planch grows in Vietnam, China, Malaysia, Indonesia as well as the drier east region of Thailand (Yamada et al., 2000). Malva nuts are harvested from this native tall tree (20–40 m tall). The dry fruit is about 25 x 15 mm, ellipsoid in shape and glabrous. Large amount of mucilaginous substance can be extracted from the fruit by soaking it in water. The mucilage, when sweetened, can be consumed as a dessert, but its principal uses are in relief of canker sore and cough.

It is also used, in China, as a traditional drug for the prevention of pharyngitis, treatment of tussis and constipation (Wang et al., 2003). Chemical analysis of an alkaline extracted malva nut gum (Somboonpanyakul

\textsuperscript{*}Corresponding author. Tel.: +1 519 824 4120x53669; fax: +1 519 824 6631.
E-mail address: sbarbut@uoguelph.ca (S. Barbut).
et al., 2004) revealed that its carbohydrate content is 83.1 g/100 g, ash 8.4 g/100 g, and protein 8.3 g/100 g. The major carbohydrates are monosaccharide arabinose (17.1 g/100 g) and galactose (15.1 g/100 g). The gum also contains 6.4 g/100 g uronic acid and small amounts of glucose, xylose and mannose; with an overall molecular weight of $3.3 \times 10^6$ Da. The gum is not commonly used as a stabilizer or a thickening agent by the food industry. The main reason appears to be the lack of reliable information on its functional properties and interactions with other food components such as meat proteins. Thus, the objectives of this study were to examine the effect of malva nut gum extract on the texture of a lean poultry meat system which includes low and regular salt and phosphate levels, and evaluate its effect on the sensory properties of a sausage type product. Overall, a better understanding of the interactions between the gum and meat proteins is important in any new product development.

2. Materials and methods

2.1. 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 left over fibrous debris was removed by a pneumatic press. The crude mucilage was precipitated with 3 volumes of 95% absolute ethanol, adjusted to 100 with distilled water and freeze-dried (Heto Drywinner DW. 8–85, Heto-Holten A/S, Allerød, Denmark). The precipitate was then sieved through 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 g/100 g, 5.87 g/100 g, 5.34 g/100 g, 2.17 g/100 g and 0.00 g/100 g, respectively.

2.2. Experiment I

2.2.1. Preparation of lean meat batters

Lean hand deboned chicken breast meat (12 kg), obtained from an Ontario local processing plant and trimmed of all visible fat and connective tissue. The meat was chopped in a bowl chopper (Schneidmeister SMK 40, Berlin, W. Germany) at the low speed setting for 1 min at $<8^\circ C$ to obtain a homogeneous mass. It was then vacuum packed in 500 g bags and kept frozen ($-20^\circ C$) for up to 4 weeks prior to use. Proximate analyses of the raw meat (AOAC, 1996) were determined in duplicate. Average moisture, protein, fat and ash contents were 74.78 g/100 g, 22.46 g/100 g, 1.62 g/100 g and 1.02 g/100 g, respectively. The meat was thawed at 4°C for 24 h and each treatment was mixed, by hand, with all the dry ingredients (Table 1) for 3 min. All visible pieces of connective tissue were removed. The treatments were stored in a refrigerator for 1 h to allow adequate equilibration. Later three 30 g aliquots were placed into polypropylene centrifuge tubes, and centrifuged (Model 225, Fisher Scientific, Pittsburgh, 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.

2.2.2. Cook loss

Fluid separated from the batters was measured after cooling for 15 min at room temperature and expressed as

\[
\text{Cook loss} = \frac{\text{g fluid expelled during cooking}}{\text{g sample before cooking}} \times 100.
\]

2.2.3. Texture profile analysis (TPA)

TPA was determined using nine cooked cores (each 1 cm high, 1.5 cm diameter) per treatment (Bourne, 1978). The samples were compressed twice to 3/4 of their original height, using a Texture Analyzer (TA-XT2, Texture

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt (g/100 g)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>TPP (g/100 g)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>CMG (g/100 g)</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td>Textural parameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracture distance</td>
<td>3.93$^{a,b,c}$</td>
<td>3.41$^{d,e}$</td>
<td>3.08$^{f}$</td>
<td>4.76$^{b}$</td>
<td>3.57$^{a,b,c}$</td>
<td>4.00$^{c,d,e}$</td>
<td>4.32$^{b,c,d}$</td>
<td>4.38$^{b,c,d}$</td>
<td>5.37$^{a}$</td>
<td>4.76$^{b}$</td>
</tr>
<tr>
<td>Springiness</td>
<td>0.28</td>
<td>0.30</td>
<td>0.34</td>
<td>0.46</td>
<td>0.48$^{a,b,c}$</td>
<td>0.50$^{a,b,c}$</td>
<td>0.59$^{b,c,d}$</td>
<td>0.32$^{a,b,c}$</td>
<td>0.71$^{a}$</td>
<td>0.62$^{b}$</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>0.26</td>
<td>0.28</td>
<td>0.29</td>
<td>0.29</td>
<td>0.29$^{b,c,d}$</td>
<td>0.32$^{a,b,c}$</td>
<td>0.33$^{b,c,d}$</td>
<td>0.32$^{a,b,c}$</td>
<td>0.71$^{a}$</td>
<td>0.62$^{b}$</td>
</tr>
<tr>
<td>Chewiness</td>
<td>2.96$^{a,b,c}$</td>
<td>3.02$^{d,e}$</td>
<td>2.57</td>
<td>4.34$^{b,c,e}$</td>
<td>5.91</td>
<td>5.14$^{a,b,c}$</td>
<td>10.41$^{b}$</td>
<td>8.84</td>
<td>13.87</td>
<td>9.77</td>
</tr>
<tr>
<td>Hardness</td>
<td>40.68$^{a,b,c}$</td>
<td>29.77</td>
<td>30.16</td>
<td>32.89</td>
<td>44.08</td>
<td>36.68$^{d,e}$</td>
<td>52.24$^{b}$</td>
<td>49.88$^{b,c}$</td>
<td>55.88$^{a}$</td>
<td>48.25$^{b,c}$</td>
</tr>
</tbody>
</table>

1Refers to salt, TPP and CMG (in rows 3,4,5) which were the dry ingredients used in meat formulations.

2Batters made with lean chicken breast meat and 33 g/100 g added water.

3Means followed by a different letter within the same row are significantly different ($P<0.05$).
Techniques Corp, Scarsdale, USA). Hardness (peak force of first curve; Newton), springiness (distance from gage to slice surface of second curve; mm), cohesiveness (ratio of area of second curve to area of first curve; dimensionless) and chewiness (gumminess \times springiness) were determined. In addition, fracture force (the force at the first significant break in the curve; Newton) and fracture distance (distance compressed prior to breaking the sample, mm) were determined.

### 2.2.4. Light microscopy

Small cooked sections (10 x 10 x 2 mm) from four treatments (1, 2, 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. Samples preparation was done in an automated vacuum infiltration unit (Sakura Tissue-Tek VIP, Sakura Finetek, Torrance, USA). The embedded samples were sectioned (Microtome HM 200, Ergostar, Walldorf, Germany) into 4 \mu m sections, dried for 40 min and stained with periodic acid–Schiff’s reagent (Elbert, 1992). A computerized image analysis system attached to an Olympus microscope (Mode BX60F5, Olympus Optical Co, Ltd., Japan) was used to view (x 20 magnification) the samples, and capture images.

### 2.2.5. Statistical analysis

The experiment was designed as a randomized complete block with 10 treatments in three independent trials. The treatment consisted of salt (0, 1, 2, 3 g/100 g), CMG (0, 0.2 g/100 g) and 0.5 g/100 g sodium tripolyphosphate (TPP; see 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, 1997).

### 2.3. Experiment II

#### 2.3.1. Preparation of frankfurters

Fresh mechanically deboned chicken meat (MDCM) was obtained from a local Thai processing plant, packed in 500 g bags and kept frozen (−20 °C) for up to 8 days prior to use. Proximate analysis of the MDCM, carried out according to AOAC (1996) was 62.97 g/100 g moisture, 12.64 g/100 g protein, 22.98 g/100 g fat and 1.02 g/100 g ash. Beef back-fat was obtained from another Thai processing plant, and ground through a 9 mm plate to obtain a homogeneous mass prior to use. Three MDCM frankfurter formulations were prepared (0.0, 0.2 and 0.6 g/100 g CMG), in three separate trials. The MDCM (15 kg per treatment) was chopped (Model K 41 RAS 661234, Maschinenfabrik Seydelmann KG, Stuttgart, Germany) at low speed for 30 s followed by adding 1.5 g/100 g salt (based on meat weight) and chopping at the high-speed setting for 30 s. This was followed by a 1.5 min break, i.e. allow time for protein extraction. Next, 2 g/100 g beef fat was added and chopped at high speed for 1 min, followed by adding 2.5 g/100 g ice, 2.5 g/100 g water, 0.015g/100g sodium nitrite, 0.045 g/100 g sodium erythrobate and a spice mix (i.e. 0.80 g/100 g dextrose, 0.27 g/100 g white pepper, 0.052 g/100 g garlic powder, 0.052 g/100 g nutmeg, 0.052 g/100 g coriander root powder) while chopping at high speed for 1 min. In the treatment with CMG, a gum solution was added at the same time together with the ice. The batters were chopped for an additional 2 min at the high-speed setting; batter temperature did not exceed 12 °C in any case. The batters were then stuffed (Model F25-TOP-1124, Albert Handtmann Maschinenfabrik GmbH & Co. KG, Biberach, Germany) into 21 mm collagen casings (Nippi Casings, Tokyo, Japan) and after 1 h in the cooler, they were smoked and cooked (Model UK 1-0/50-70 kg, GmbH & Co. KG, Waxweiler, Germany). The procedure included drying at 50 °C for 25 min, heating to 55 °C for 12 min, applying the smoke for 22 min and continuing heating in steps up to 74 °C. Relative humidity was gradually increasing up to 100% at the end. The frankfurters were then cold showered for 30 min, kept overnight at 3 °C, vacuum packed and stored at 5 °C.

#### 2.3.2. Cook loss

The weight of the sausage before and after cooking was measured and expressed as

\[
\text{Cook loss} = \frac{\text{g sausage after cooking} \times 100}{\text{g sausage before cooking}}.
\]

#### 2.3.3. Texture profile analysis (TPA)

TPA was determined as described above.

#### 2.3.4. Color

Color of cut sausage surfaces (nine pieces per treatment) was measured using a colorimeter (Model CR-300, Minolta, Co., Ltd., Osaka, Japan) and expressed as Hunter L (lightness), a (redness) and b (yellowness) values. The results are expressed as the average values from the three different trials.

#### 2.3.5. Sensory analysis

Trained panelists, experienced in the sensory evaluation of various meat products were employed. They consisted of six graduate students and staff in the Department of Food Technology, Chulalongkorn University. The cooked samples were identified by a 3-digit random number placed on a round plate. The samples were reheated in a microwave oven for 30 s and served at 45 ± 4 °C. Descriptive sensory evaluations were recorded by the panelists (Stone, Sidel, & Oliver, 1974). The structured linear scales on ballots were coded on a ten point basis. Attributes included color (1 = brown, 10 = brownish pink), texture (1 = very soft, 10 = very firm), elasticity (1 = low elasticity, 10 = high elasticity), juiciness (1 = very dry, 10 = very juicy), flavor (1 = unpleasant, 10 = extremely pleasant), and
overall acceptability (1 = unacceptable, 10 = extremely acceptable).

2.3.6. Statistical analysis

The experiment was also structured as a randomized complete block design with three treatments in three independent trials. The treatment consisted of three levels of CMG (0, 0.2, 0.6 g/100 g). Differences among treatment means were tested by Duncan’s multiple range test. SAS version 6.12 was used to perform the statistical analysis (SAS, 1997).

3. Results and discussion

3.1. Experiment I

3.1.1. Cook loss from lean chicken batters

There was an overall decrease in cook loss as salt level was increased from 0 to 3 g/100 g (Fig. 1A). Higher salt allowed more meat protein extraction and thus more moisture binding. Schults and Wierbicki (1973) also showed that increasing salt from 0 to 1 g/100 g reduced cooking shrink of chicken meat from 35 to 18 g/100 g, but using 2 or 5 g/100 g salt resulted in a similar 16 g/100 g shrink. Gordon and Barbut (1992) reported that increasing NaCl from 1.5 to 2.5 g/100 g resulted in a higher protein extraction and enhanced protein extraction (i.e. determined by gel electrophoresis) in chicken breast meat batters. This implies that higher level extracted more salt soluble meat proteins and further enhanced network formation. Treatment 10 showed the low cook loss due to the combination of high salt, 0.5 g/100 g TPP and 0.2 g/100 g CMG. Adding TPP and CMG helped to further reduce the cook loss (15.92 to 9.97 g/100 g; Trt. 5 vs. 10; Fig. 1A). TPP is known to act synergistically with NaCl, and increases the water holding capacity of different meat preparations (Huffman, Cross, Campbell, & Cordray, 1981; Moore, Theno, Anderson, & Schmidt, 1976; Neer & Mandigo, 1977), as well as stabilizes color, increases binding among meat particles, and improves cooking yield (Rongey & Bratzler, 1966; Sherman, 1961a, b; Swift & Ellis, 1957). Pepper and Schmidt (1975) reported that a 2.0 g/100 g NaCl and 0.5 g/100 g phosphate was an optimal combination for obtaining the highest cook yield in beef rolls. Dziezak (1991) reported that the addition of 0.2–0.5 g/100 g guar gum to sausages could bind the 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) reported that moisture loss, during cooking, was reduced from 10 to 6 g/100 g when 0.35 g/100 g carboxymethylcellulose was added to low-fat pork/beef frankfurters. Berry and Bigner (1996) also reported that adding 1.5 g/100 g salt with 0.38 g/100 g iota carrageenan improved cooking yields, juiciness and tenderness scores of partially cooked nuggets compared with an all-pork nugget produced without the gum and salt.

3.1.2. Textural properties of lean chicken batters

Fracture force and springiness showed an overall increase when salt level was raised (Fig. 1B, Table 1). The high salt level in treatments 7 and 8, helped to extract more proteins, which improved the binding. This agrees with Barbut and Mittal (1989), who indicated that cooked poultry meat batters became more rigid when a higher salt is level used, as more proteins are extracted. Treatment 9 showed high numerical fracture force, fracture distance, springiness, cohesiveness, chewiness and hardness (Fig. 1B, Table 1) because the TPP resulted in further protein solubilization, which during heating increased binding among meat particles. Addition of salt and/or polyphosphate to meat products has been reported to improve water-binding ability (Hellendoorn, 1962; Schults & Wierbicki, 1973). Theno, Siegel, and Schmidt (1978) reported that sectioned and formed hams showed high degree of alignment, when ≥2 g/100 g salt and phosphate were added. The main mechanisms associated with phosphate activity in meat are believed to be: increasing ionic strength, acting as polyanion, shifting the pH from the meat isoelectric range, sequestering metal ions and dissociating actomyosin to some extent (Sofos, 1986). However, cohesiveness and chewiness of the cooked chicken batter with 2 g/100 g salt and TPP (Trt. 9) was reduced by the addition of 0.2 g/100 g

![Fig. 1. Means for cook loss (A) and fracture force (B) of lean chicken batters containing different levels of salt, sodium tripolyphosphate (TPP) and crude malva nut gum (CMG). Bars with different letter are different (P<0.05). Treatment numbers are: 1 = 0 g/100 g salt + 0 g/100 g CMG; 2 = 0 g/100 g salt + 0.2 g/100 g CMG; 3 = 1 g/100 g salt + 0 g/100 g CMG; 4 = 2 g/100 g salt + 0.2 g/100 g CMG; 5 = 2 g/100 g salt + 0 g/100 g CMG; 6 = 2 g/100 g salt + 0.2 g/100 g CMG; 7 = 3 g/100 g salt + 0 g/100 g CMG; 8 = 3 g/100 g salt + 0.2 g/100 g CMG; 9 = 2 g/100 g salt + 0.5 g/100 g TPP + 0 g/100 g CMG; 10 = 2 g/100 g salt + 0.5 g/100 g TPP + 0.2 g/100 g CMG.](image-url)
CMG (Trt. 10, Table 1). This might be explained by some gum interference with the binding, without affecting meat batter stability (i.e. cook loss). The high molecular weight of CMG (3.3 × 10^6 Da) probably obstructed the construction of the protein matrix in the chicken batter. Foegeding and Ramsey (1986) also reported that increasing xanthan gum (anionic gum) concentration, decreased meat batter hardness without affecting batter stability. Later, Montero, Hurtado, and Pérez-Mateos (2000) found that the presence of xanthan gum produced a decrease in gel forming capacity of myofibrillar protein from fish (Blue whiting), which was reflected in poorer resistance to their folding test and lower values of breaking force, penetration work and hardness. They further explained that the high molecular weight of xanthan might have hindered protein network formation and resulted in large cavities in the matrix. Other studies by Elfak, Pass, and Phillips (1979) reported gum and protein interactions between anionic gum (xanthan gum) and casein, but not between casein and neutral gums (locust bean and guar gum). Fox, Ackerman, and Jenkins (1983) also reported that xanthan gum and carrageenan (both anionic gums), could stabilize the texture of pickled frankfurters while neutral gums such as guar, arabic and locust beans gum had no effect.

3.1.3. Light microscopy of lean chicken meat batters

The micrographs (Fig. 2) show differences among the treatments. Overall, the no salt treatment (Fig. 2A) showed a much more open structure compared to the 2 g/100 g salt treatment (Fig. 2B). This is because salt extracted more proteins and resulted in a denser protein matrix formation. Increasing NaCl from 1 to 2 g/100 g improved the stability of the meat batters, as was evident by the lower cook loss (Fig. 1A). Trout and Schmidt (1986a) indicated that the ionic environment of a whole muscle system affects its water-binding ability. The addition of salt to a meat batter influences the amount of protein extracted (Gordon & Barbut, 1992) and hence the structural, density and stability of the meat product. Structural changes are affected by alterations in the electrostatic and hydrophobic interactions among proteins (Trout & Schmidt, 1986a, b) or by effects dependent on the specific properties of the ions involved (Asghar et al., 1985). Treatment 2 (Fig. 2C) showed a fairly similar structure to Trt. 1 but with a residual malva nut gum particle. It is possible that the gum interacted with the meat protein matrix; e.g., occupying some of the interstitial spaces within the matrix structure and resulted in increasing gel strength of the batter (Table 1). The treatment with 2 g/100 g salt and 0.2 g/100 g CMG gum (CMG) (Trt. 2), and (D) with 2 g/100 g salt and 0.2 g/100 g CMG (Trt. 6), Arrowheads are pointed to CMG particles. Bar = 100 μm.
(Trt. 6; Fig. 2D) showed a consolidation of the protein matrix as well as residual CMG particles in between some muscle fibers (see arrow in Fig. 2D). The result of this microstructure is associated with both the gum presence and the salt extracting more myofibrillar proteins, which resulted in more binding within the system.

3.2. Experiment II

3.2.1. Cook loss from commercial type frankfurters

Cook loss was significantly affected by CMG level. Treatment 3 showed the lowest cook loss (2.24 g/100 g, Table 2). This seems to be due to the highest level of CMG (0.6 g/100 g), which enabled more moisture binding. In other studies such as Whiting (1984), adding 0.1–0.3 g/100 g alginate or xanthan gum showed an improvement in water binding in beef frankfurters. Barbut and Mittal (1996) found that moisture loss during cooking of low-fat pork/beef frankfurter was reduced from 10 to 6 g/100 g due to the addition of carboxymethylcellulose. Lurueña-Martínez, Vivar-Quintana, and Revilla (2004) also reported that addition of locust bean/xanthan gum into pork frankfurters significantly increased cooking yield, improved emulsion stability and decreased jelly and fat separation. This experiment demonstrated that CMG was more effective in retaining moisture in cooked poultry frankfurters than the control frankfurter without CMG.

3.2.2. Color of frankfurters

The addition of CMG significantly reduced the lightness (L) and redness (a) of the frankfurters (Table 2). This could be explained by the higher amount of the dark-colored CMG in the frankfurters. Mittal and Barbut (1993) also found that the lightness values of low-fat pork breakfast sausages were reduced due to the addition of carboxymethylcellulose and microcrystalline cellulose. No effect of CMG was noticed on yellowness (b) value of the frankfurters.

3.2.3. Textural properties of frankfurters

Table 2 shows the effect of CMG levels on textural properties of frankfurters. Adding 0.2 and 0.6 g/100 g of CMG (Trts. 2 and 3) resulted in higher hardness, springiness and chewiness values compared to the no CMG frankfurters (Trt. 1); however CMG level had not affected cohesiveness. The increases mentioned above might be explained by the interactions of CMG with the chopped meat particles and hence the gel strength of the frankfurters. The frankfurters with the highest level of CMG (0.6 g/100 g) resulted in the hardest product (22.81 N, Table 2). This might have been due to the high level of gum that increased the binding among meat particles more than the low CMG treatment. Springiness values also showed an increasing trend as the gum level was increased. The increase was mainly because CMG altered the gel structure and increased binding within the product. Moreover, chewiness behaved similarly to hardness. The maximum chewiness values was obtained for the 0.6 g/100 g CMG frankfurters (Trt. 3, Table 2). It appears that CMG improved the texturral properties of the frankfurters better than in the cooked lean chicken breast meat because the emulsification process increased salt soluble protein content and allowed more binding among the meat and gum.

3.2.4. Sensory properties of frankfurters

Table 3 shows the effect of CMG level on sensory properties of the frankfurters. The panel’s scores for color revealed major differences in the perceived color of the frankfurters, which are in agreement with the instrumental color evaluation (Table 2). Overall the no CMG frankfurters were evaluated by the panel as more pink than the frankfurters with 0.6 g/100 g CMG. This agrees with the objective color measurement that the no CMG frankfurters showed higher L and a values than the frankfurters with 0.6 g/100 g CMG (Table 2). The panel found that firmness and elasticity significantly increased by increasing the CMG content. This agrees with the objective texture analysis that showed higher hardness, springiness and chewiness values than in the no CMG frankfurters. The addition of CMG resulted in products perceived to be less juicy than the control (without CMG). The CMG added frankfurters (Trts. 2 and 3) were perceived to be more firm and elastic than the control (Trt. 1). No effect of CMG on the flavor of frankfurters with 0.2 and 0.6 g/100 g CMG content (Trts. 2 and 3) was detected. Moreover, the frankfurters with 0.2 g/100 g CMG showed significantly higher flavor scores (8.41, Table 3) than the control (without CMG). The overall acceptability results indicated that the panelists preferred the frankfurters with 0.2 g/100 g CMG (Trt. 2). That could have been due to the more firm

Table 2

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Texture profile analysis</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hardness (N)</td>
<td>Springiness</td>
</tr>
<tr>
<td>#</td>
<td>CMG (g/100 g)</td>
<td>Cook loss (g/100 g)</td>
</tr>
<tr>
<td>1</td>
<td>0.0</td>
<td>2.92&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>2.55&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>0.6</td>
<td>2.24&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a–c</sup>Means followed by a different letter within the same column are significantly different (P<0.05).
and elastic product as well as the color of this product which was not too dark as the frankfurters with 0.6 g/100 g CMG (Trt. 3). Overall, the 0.2 g/100 g CMG frankfurters (Trt. 2) can be produced with a high degree of consumer acceptance.

In the first experiment (lean meat), addition of CMG into the batter with 2 g/100 g salt and TPP resulted in lower cohesiveness and chewiness when compared with the batter with only 2 g/100 g salt and TPP. On the other hand, in the second experiment (emulsion type), addition of CMG and TPP resulted in higher hardness, springiness and chewiness of the frankfurters. This is probably because the chopping process actually resulted in finely chopping the mixture of MDCM and other ingredients. Thus, the salt could effectively extract a higher amount of salt soluble meat proteins from the MDCM. The later formed a stronger protein matrix. Moreover, CMG was effectively mixed with the batters and enhanced the binding among meat particles, hence increasing gel strength of the products.

4. Conclusions

In summary, the results indicate that increasing salt level and adding CMG at the 0.2 g/100 g level was beneficial in reducing the overall cook loss. Addition of 0.2 g/100 g CMG affected cohesiveness and chewiness of lean cooked chicken meat batters with 2 g/100 g salt and TPP. In commercial type frankfurters, 0.2 g/100 g CMG addition can be very beneficial in increasing cooking yield and improving textural properties. Furthermore, the frankfurters with 0.2 g/100 g CMG were the most acceptable. The results point to a potential use of malva nut gum by the meat industry.

Acknowledgments

The authors would like to thank Office of the Commission for Higher Education, Thailand for financial support, Department of Animal and Poultry Science and Department of Food Science, University of Guelph, Canada for their contribution.

References


