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Evaluation of Physicochemical Properties of Chicken Sausages Containing Whey Protein Isolate and Guar Gum

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Abstract

The present work aims to evaluate the physicochemical properties and proximate composition of adding whey protein isolate (WPI) and guar gum (GG) as emulsion gels in chicken sausages formulated with different fat percentages. The fat reduction resulted in products having lower moisture content \( p < 0.05 \) than control samples. The protein, fat, ash, and carbohydrate contents for the formulated chicken sausages were significantly \( p < 0.05 \) different, in the range from 15.58% to 20.71%, 11.59%–16.83%, 4.88%–6.61% and 27.86%–34.77% respectively. Treatment E10 had the highest cooking yield and moisture content out of all treatments. Furthermore, the increase of WPI and GG mixture in the formulation was observed to improve the cooking yield \( p < 0.05 \) and showed to decrease the TEF% significantly \( p < 0.05 \). The results found that the addition of WPI and GG increased the %WHC but the values were lower than the control chicken sausages. This analysis suggests that the addition of WPI-GG can be effective as a fat replacer.

Keywords: Guar gum, Whey protein isolate, Proximate composition, Physicochemical

1. Introduction

Chicken sausage is a popular ready-to-eat breakfast menu item by consumers because of its practicality to cook. Throughout the years, the demand for chicken sausages has increased and many people have been looking for low-calorie and low-fat alternatives. Chicken sausages contain no more than 40% fat (Brunei Public Health (Food) Act, 2001) and any absence of fat will have an unacceptable texture and mouthfeel to the consumers. Subsequently, many food products have used other food ingredients and additives to mimic fat's texture and functional and flavour characteristics. Several studies have explored the different approaches to reduce or replace fat and still maintain the characteristics of fat that used plant starches and carrageenan in chicken patties, olive oil as a fat replacer and formulated with unripe banana by-products and pre-emulsified sunflower oil (Das et al., 2015; Nieto & Lorenzo, 2021; Pereira et al., 2020). Protein-based fat replacers including whey protein, soy, pea and milk-derived proteins are mainly preferred in low-fat meat products because of their high nutritional value and functional properties including solubility, viscosity and water binding capacity (Naga Mallika et al., 2009). On the other hand, gums, and gelatin are carbohydrate-based fat...
replacers which work well in high moisture systems such as low-fat spreads and meat emulsions (Giese, 1996). Both fat replacers were used in the formulation of the current study. The use of whey protein isolate (WPI) and guar gum were used in a gel-filled emulsion, as one of the many different approaches available to reduce fat in meat products. Furthermore, guar gum is used as a dietary fibre supplement food, and one of the many health benefits of consuming is that it lowers the cholesterol level in the body and significantly reduces the risk of heart disease (Mudgil et al., 2014). Whilst, whey protein in food products can increase nutrient levels, and it is versatile as it can be carried out by altering the different characteristics of whey (Chandrajith & Karunasena, 2018). Additionally, it was shown that whey protein and guar gum interaction have good biocompatibility (Farshi et al., 2019; Fitzsimons et al., 2008) found that the incorporation of guar gum and whey protein gels could have maximum benefit when the formulation and processing conditions were carefully considered.

This study aimed to assess the potential of using whey protein and guar gum as a fat replacer in chicken sausages. Furthermore, given the lack of detailed studies on the effects of the addition of whey protein isolate and guar gum on chicken sausages, it was then decided to investigate the physicochemical and proximate composition of chicken sausages at different inclusion levels.

2. Materials and methods

2.1. Materials

Fresh breast chicken cuts obtained from the local supermarket were all trimmed off all connective tissue and visible fats and frozen overnight before being minced using a 6 mm sieve by a meat mincer (AIFA, Model MG-N528). Whey protein isolate containing 100% pure whey isolate (LushProtein, Singapore), a food-grade commercial preparation of whey protein isolate and guar gum on chicken sausages, it was then decided to investigate the physicochemical and proximate composition of chicken sausages at different inclusion levels.

2.2. Methods

2.2.1. Preparation of emulsion gel

Firstly, an emulsion gel is prepared and refrigerated before being added with ground chicken and other ingredients. The emulsion is prepared by emulsifying WPI with distilled water using a food blender (KENWOOD, BL220 series) for 2 min. Then, oil was added and homogenized for 5 min. Finally, guar gums (GG) and sesame seed flours were added and homogenized for 3 more minutes until reached a thick consistency. The ground meat was thawed prior to use, then placed in a food processor with the prepared emulsion gels together with salt, garlic powder, and mixed herbs, mixed until the desired emulsion was achieved for about 1 min and the temperature was between 12 °C and 15 °C, measured using a hand-held thermometer. The uncooked batter from each formulation was stuffed manually into a food-grade plastic sausage casing of 50 mm diameter.

2.2.2. Product formulation

All formulations were prepared with the same common ingredients: 70 % raw chicken meat and 30 % added fat and water. Three levels of fats were studied (2 %, 5 %, and 10 %) with the corresponding water additions of 28 %, 25%, and 20 % respectively. The water is needed to maintain the content of fat to-meat ratio in normal sausages constant of 3:7 respectively. The control (CON) chicken sausage consists of 70 % lean breast meat without any animal fats. For each treatment, 100 ± 1 g of chicken sausages are measured and duplicated three times. The formulation percentages of all ingredients are stated in Table 1 nine different types of oil-in-water emulsion gels. The first three types of emulsion gels were prepared with a stabiliser system based on sesame seed flour (S) and Whey Protein Isolate (WPI) only. Whilst, three types of emulsion were prepared with 50 % WPI and 50 % Guar gum (E) and another three types of emulsion gels consisted of 70 % WPI and 30 % Guar gum (GM).

Sausages were cooked using a conventional oven, at 175 °C until the internal temperature of the sausages reached 70 °C for 3 min, measured using a handheld digital thermometer (Henning et al., 2016). The cooked sausage samples were stored under refrigeration (4 ± 1 °C) before analysis.

2.3. Proximate analysis

All samples were analysed in accordance with the standard AOAC methods (AOAC, 1995). Moisture content was determined by weight loss after 18 h of drying at 100 °C in a drying oven (Universal Oven UF110, Memmert). Protein content was determined by the Kjedahl method. Fat content was determined by extracting samples in a Soxhlet apparatus using petroleum ether as a solvent. Ash was determined according to the AOAC method using a muffle furnace and carbohydrate was calculated by computing the difference.
2.4. Water holding capacity

Water-holding capacity (WHC) was measured by the method developed by Kim et al. (2011) with modification. Ten grams of sausage samples were measured and prepared in a glass jar to be heated for 30 min in a water bath (70 °C). After heating, the samples were removed and cooled before being wrapped in cheesecloth, and centrifuged for 10 min at 1000 rpm (Centrifuge model 800D). The cheesecloth was removed and the sample weight was measured again. All measurements were performed in triplicates. WHC (%) is calculated as the percentage of weight loss during centrifugation.

2.5. Cooking yield

After cooking in the oven, the cooked chicken sausage samples were cooled for 30 min. The sausage samples were weighed before and after cooking. Cooking yield was calculated from the weight difference between uncooked and cooked samples and expressed as a percentage (Hadi-pernata et al., 2016).

2.6. Moisture retention

Moisture retention value represents the amount of moisture retained in the cooked sample per 100g of sample. This water retention was determined as described by Verma et al. (2016) and the equation by El-Magoli et al. (1996).

2.7. Emulsion stability

The emulsion stability of the meat batters (before cooking) was evaluated as the total expressible fluid (TEF) using the procedure of Hughes et al. (1997) with modification. Samples of approximately 25g were weighed and centrifuged (Centrifuge model 800D) for 1 min at 3000 rpm in 15 mL centrifuge tubes. Then, the samples were heated in a water bath for 30 min at 70 °C. The samples were cooled before being centrifuged again for the second time for 3 min at 3000 rpm. All samples were repeated in three replicates. The results were expressed in percentage and was calculated as follows:

\[
\text{TEF} = \left(\frac{\text{weight of centrifuge tube and sample}}{\text{weight of centrifuge tube and pellet}}\right) \times 100\% \\
\text{(Eq.1)}
\]

2.8. Statistical analysis

Two-way analysis of variance (ANOVA) was performed to evaluate the significant difference \((p < 0.05)\) in the effect of the sausage samples. Tukey's HSD test was used to identify significant differences between all formulations and storage time. A \(p < 0.05\) value was considered to indicate statistical significance. All results in the tables are given in terms of mean values and standard deviation.

3. Results and discussion

A significant difference \((p < 0.05)\) in proximate characteristics was observed between all the formulations (Table 2) in mean values of moisture, protein, fat, ash, and carbohydrate contents. The moisture content of the added WPI and GG sausages was significantly \((p < 0.05)\) higher than CON sausages, which could be attributed to the desired

<table>
<thead>
<tr>
<th>Sample</th>
<th>Gelling Agent/g</th>
<th>Chicken Breast Meat/g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sesame Seed Flour/g (S)</td>
<td>100% Whey Protein/g (W)</td>
</tr>
<tr>
<td>W2</td>
<td>6</td>
<td>0.6</td>
</tr>
<tr>
<td>W5</td>
<td>6</td>
<td>1.5</td>
</tr>
<tr>
<td>W10</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>E2</td>
<td>6</td>
<td>0.3</td>
</tr>
<tr>
<td>E5</td>
<td>6</td>
<td>0.75</td>
</tr>
<tr>
<td>E10</td>
<td>6</td>
<td>1.5</td>
</tr>
<tr>
<td>GM2</td>
<td>6</td>
<td>0.42</td>
</tr>
<tr>
<td>GM5</td>
<td>6</td>
<td>1.05</td>
</tr>
<tr>
<td>GM10</td>
<td>6</td>
<td>2.1</td>
</tr>
<tr>
<td>CON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample</td>
<td>CON</td>
<td>W2</td>
</tr>
<tr>
<td>--------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>Moi. (%)</td>
<td>20.57 ± 0.13c</td>
<td>26.69 ± 2.60b</td>
</tr>
<tr>
<td>Prot. (%)</td>
<td>21.81 ± 0.45a</td>
<td>21.61 ± 0.59b</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>13.78 ± 0.62b</td>
<td>12.06 ± 0.31a</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>5.75 ± 0.02ab</td>
<td>6.11 ± 0.06a</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>38.09 ± 1.09a</td>
<td>38.09 ± 0.86b</td>
</tr>
<tr>
<td>Cooking Yield (%)</td>
<td>83.71 ± 1.34</td>
<td>84.48 ± 0.86</td>
</tr>
<tr>
<td>Moisture Retention (%)</td>
<td>38.09 ± 1.09a</td>
<td>38.09 ± 1.09a</td>
</tr>
</tbody>
</table>

Table 2: Proximate composition, cooking yield and moisture retention of chicken sausages.

Diez (1991) suggested that the differences in fat content in all treatments. The results showed that the fat content has ranged from 11.59% to 16.83%, with GM10 as the highest. Any fat reduction in the formulation can significantly affect the acceptability of a product because of the increase in the toughness of meat products. Furthermore, the fat content values were higher than compared to previous studies of chicken products; chicken patties using plant starches and carrageenan as fat substitutes with a fat content of 9.68% (Das et al., 2015), chicken sausages supplemented with a winter mushroom powder of 2.94% of crude fat (Jo et al., 2018). This could be due to the use of soybean oil in the formulation, which added to the fat content of the results and this is supported by a study that used corn oil partially for processing dry-fermented chicken sausage which has a fat content of 16.96% (Menegas et al., 2017).
Ash content of the samples significantly (p < 0.05) differ from each treatment. The addition of WPI and GG resulted in a higher level per cent of ash content when compared to control treatments. The highest ash content for the sausages was obtained for WPI-only, W5 treatment samples (p < 0.05) compared to other treatments and the control. However, when compared with results obtained from a previous study, the ash content of chicken sausages ranged from 2.7% to 2.8% (Andrés et al., 2006), and those of commercial chicken sausages in Malaysia ranged from 2.1% to 3.3%. This increase in ash content could be because of the addition of spices for seasoning, starches, cereals, legumes, and soy protein (Babji et al., 2000).

The lowest carbohydrate content values are obtained in sample W2 with 27.86% and CON samples have the highest carbohydrate content with 38.09%, the difference between them is statistically significant (p < 0.05). The carbohydrate content values can also be further supported by the decrease in protein content in the present study. Similarly, the present study also had a higher mean of carbohydrate contents compared to previous studies; dry fermented sausage has ash content ranging from 3.2% to 3.4% and only increased to 5.5–6.5% after 34 days of storage (Menegas et al., 2017). Moreover, the carbohydrate content of chicken sausage formulated with chia seeds ranged from 1.1% to 1.4%, and the carbohydrate content of low-fat chicken sausage from 2.2% to 2.7% (Reddy et al., 2012). According to (Huda et al., 2010), the increase in carbohydrate content is because of the use of increasing starch content to substitute raw meat.

In the present study, there was a statistically significant (p < 0.05) difference in the cooking yield and moisture retention of the sausages with the addition of WPI and GG. Among all the treatments, E10 recorded the highest cooking yield of 93.85% and moisture retention of 27.42%. Other treatments recorded cooking yield and moisture retention ranged from 77.95% to 88.07% and 22.92%–25.06% respectively. Cooking yield is a significant parameter in predicting the behaviour of products during cooking (Pietrasik & Li-Chan, 2002). The cooking yield increases with the increase of the gum mixture, evident in E and GM treatments in the formulation because of the high water-binding ability of the gums. Similarly, these results were also observed in the report of using a guar-xanthan gum mixture (Rather, Masoodi, Akhter, Gani, et al., 2016).

Additionally, the treatments with WPI-only were not significantly (p > 0.05) different from the control sample and these results agreed with other studies that added liquid whey to cooked ham (Pereira Dutra et al., 2012) and frankfurter-type sausages (Yetim et al., 2006).

The samples with the addition of WPI and GG had lower moisture retention than previous studies that used a gelling agent; carrageenan and guar gum on low-fat meatballs had moisture retention ranging from 47.69% to 62.99% (Ulu, 2006), and in low-fat Kadaknath chicken patties that used gum having values from 53.95% to 54.94% (Badole et al., 2021). Contrary to these previous studies, the results of the present study had significantly (p < 0.05) higher moisture retention in the added WPI and GG mixture (E and GM treatments) compared to WPI-only treatments and CON. This is probably because the WPI-GG mixture had better water binding ability than WPI alone. Furthermore, the low moisture retention value for control could be because of the addition of extra water used in the formulation and the water absorption capacity of sesame seeds in the treatments (Gorachiya, 2021).

The influences of the incorporation of WPI and GG on water-holding capacity and emulsion stability are represented in Fig. 1. The emulsion stability was significantly (p < 0.05) different in treated sausages with W5 having the highest (12.4 TEF%)
total expressible fluid and followed closely by Control (12 TEF%). However, these values are in contradiction to having emulsion stability lower than in the previous studies of using oat flour on chicken sausages, which was much higher ranging from 81.08% to 87.87% and 23%–27.43% in the application of guar-xanthan gum in meat emulsions (Rather, Masoodi, Akhter, Rather, et al., 2016; Reddy et al., 2012). These low values in emulsion stability are aligned with the results of lower moisture retention values. The higher the value of TEF% which is the per cent fluid released, means a larger amount of water was added to be coupled with gel formation. This contributed to more liquid being released after cooking (Rather, Masoodi, Akhter, Gani, et al., 2016). Moreover, within each fat level additions of WPI and GG in the formulation caused a decrease in total expressible fluid (p < 0.05).

The mean water holding capacity of WPI and GG added treated sausage products was found to be significantly (p < 0.05) different compared to control samples. The control (CON) had the highest (50.98%) water-holding capacity percentage and followed closely with E2 (46.95%) and W2 (46.36%). The percentage of water loss decreased significantly as more whey protein and guar gum were added to the sausages, except for E10 which has a slight significant (p < 0.05) increase. This has a similar pattern to the study that found an increase in gum mixture resulted in an increase in water-holding capacity in low-fat emulsions (Ayadi et al., 2009). It is observed that sausage with only WPI in them has significantly higher values of water loss than treatments with mixed WPI and GG. This could be because the amount and type of polysaccharides used in the formulation are closely related to water holding capacity. The dietary fibre can also modify textural properties and improve shelf-life in food products (Elleuch et al., 2011). The addition of GG in the formulation appeared to be effective in increasing the WHC which has been previously shown to increase in other food products (Popova et al., 2017).

4. Conclusions

The proximate composition and physicochemical results showed significant differences (p < 0.05) throughout all the tested formulations. This study demonstrated that the addition of emulsion gels as fat replacers to chicken sausages provides a high % WHC which could help with the eating quality such as the texture of the products. In addition, the moisture retention values of all treatments were much lower than previous studies showing that little moisture was released during cooking. The treatments with a mixture of WPI-GG enhanced the cooking yield and moisture retention of the chicken sausages better than treatments with only WPI. The present study showed that the WPI and GG mixture is a viable alternative for fat replacers in meat products.

Conflict of interest

We declare that there is no conflict of interest regarding the publication of this paper.

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