Production of Functional Low-Fat Chicken Burger

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Abstract: Healthier lipid formation based on processing strategies is one of the most important current approaches to the development of new functional products. The physical properties and sensory evaluations of low fat chicken burger (2.75%) with optional substitution of carrageenan (0.4 %), potato starch (2.5%), carboxymethyl cellulose CMC (0.7%) and maltodextrin (0.7%) aside with a control sample were studied. All samples were stored at -20 °C for 3 months. The obtained data has revealed that, the presence of maltodextrin as a fat replacer has no effect on cooking loss and shrinkage during storage period, while shear force and L* (lightness) were increased. Sensory evaluation of the same sample was significantly higher than those formulated with other fat replacers during storage period. On the other hand, replacing fat with potato starch could be considered as the second best formula for both physical and sensory evaluations compared with other studied samples. The effect of CMC and carrageenan were less pronounced and less acceptable than that of all other samples.

Key words: Fat Replacer, Chicken Burger, Carrageenan, Sensory Evaluation, Physical Properties, CMC, Maltodextrin, Potato Starch.

INTRODUCTION

Fat is a Food component, it contributes key sensory and physiological benefits. Fat contributes to flavor, or the combined perception of mouth feel, taste and aroma/ odor (Moghazy, 1999). Many efforts have been made to improve the quality and stability of burgers, because consumers demand for healthy fast food has rapidly increased in the recent years (Papodina and Bloukas, 1999).

Non meat ingredients are useful in emulsified meat products because of their functional properties such as emulsification of both texture and appearance. Troy et al., (1999) studied the use of tapioca starch, carrageenan, oat fiber, pectin and whey protein as replacers in low-fat beef burger. The samples were tested for cooking yield, water holding capacity, retention of shape, sensory and mechanical texture analysis. Fat substitutes when blended together had the ability to improve the cooking characteristics and in particular lowered shear force, due to the ability of these ingredients to retain water and hold it during cooking.

The desirable sensory characteristics of juiciness and mouth feel of a ground meat patty are associated with higher fat levels. To retain these characteristics when fat contents are reduced, binders are used. Binders can be added to meat formulations to improve water and fat- binding properties, as well as to improve cooking yields, slicing characteristics and flavor (James, 1992). Binders are also used to reduce formulations costs.

In meat products there are generally two types of binders: the first is used in sectioned and formed products to bind separate meat pieces, the second type: is used to increase water- binding capacity. It is the second that is of importance in formulating low-fat meat patties.

Carrageenan, a seaweed gum is finding widespread application in low-fat meats. Carrageenan is being used with good results in ground beef patties as a binder and extender due to its ability to retain moisture. (Malika et al., 2009).

Maltodextrin (dextrose equivalent less than 20) may be used as binder up to 3.5% in finished meat products created by cleaving starch amylase and amylopectin chains. The advantage of maltodextrins in meat products are their low cost and ease of use (Berry, 1991).

Researchers appeared to support the growing potential of potato starch for use in various food application as a thickener, an emulsion stabilizer, suspending agent, gelling agent, fiber source, mouth feel improver and fat replacer (Stephan, 2008).

Carboxymethyl cellulose (CMC) or cellulose gum is a cellulose derivative with carboxymethyl groups bound to some of the hydroxyl groups of the glucopyranose monomers that make up the cellulose backbone. CMC is used in food science as a viscosity modifier or thickener and to stabilize emulsions in various products including ice cream. It is used primarily because it has high viscosity, is non-toxic ad is non-allergenic, Codex Alimentarius (2009).

Generally, the low-fat meat and chicken products have generated a variety of strategies for reducing fat, but the final goal has been to reduce fat with retaining traditional full-fat flavor, taste and texture. So, the aim of this work is to produce a low-fat chicken burger by using different fat replacers and evaluate them physically and organolytically during storage time (-20°C).

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MATERIALS AND METHODS

Materials:
- Chicken meat (breasts) were obtained from local market and minced using mincer (home mincer). Carrageenan type CSM-2 was obtained from Copenhagen pectin ALS. A division of Hercules. Denmark.
- Spice mixture, salt, fresh onion, garlic and parsley were obtained from the local market.
- Maltodextrin powder was obtained from Starch and Glucose Company Cairo Egypt.
- Carboxymethyl cellulose was in chemical grade.
- Potato Starch was isolated from potatoes by the modified methods of Parameter (1969). Trease and Evans (1978) and Meyer (1982).

The tubers were weighted out, washed and steeped in potassium metabisulphite (0.81339/ K₂SO₄) at 29±1.0 °C for 48 hr. The steeping water was changed after 24 hr. The tubers were then milled using a Moulinex type 276 mill to slurry which was suspended in K₂SO₄ solution, stirred and allowed to stand for 2 min. then the starch milk was stirred again and passed through a 100-mesh sieve cloth (coarse sieving). The suspension was allowed to stand for 24hr., then the supernatant was decanted, the starch sediments was collected and resuspended in pure water. The starch milk was then passed through a 260-mesh sieve (fine sieving) Moorthy et al., (1994) and the suspension allowed setting for 8 hr., the resulting wet starch cake was crushed manually, sun-dried for 24hr., then oven-dried at 50°C for 3hr.

Methods:
Chicken Burger Preparation:
Chicken burger formulas LF1, LF2, LF3, LF4 and LF5 were prepared by mixing well minced chicken breast with different fat replacer and other ingredients which are presented in Table (1). The burger formulas were formed using burger form. All samples were partially cooked in microwave (Gold star ER-535 MD, input 220v-50HZ, frequency 2450 MHz having maximal energy of 0.98 KW at 100% power ) for 1.5 min. at each side then frozen for up to 90 days at –20°C and samples were completely cooked, analyzed and evaluated at interval (45 and 90 days).

Table 1: Composition of formulated chicken burger%.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>LF1</th>
<th>LF2</th>
<th>LF3</th>
<th>LF4</th>
<th>LF5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minced chicken meat</td>
<td>92.35</td>
<td>90.25</td>
<td>92.05</td>
<td>92.05</td>
<td>92.75</td>
</tr>
<tr>
<td>Fat - replacer</td>
<td>0.40</td>
<td>2.50</td>
<td>0.70</td>
<td>0.70</td>
<td>0.00</td>
</tr>
<tr>
<td>Salt</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Onion</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Garlic</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Parsley</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Mixed spices</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Iced water</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Cooking of Chicken Burger:
Samples under investigation, at zero time and during storage period were grilled on electrical heater in a non sticky pan with no added fat, for 2.5 min. at each side to complete cooking.

Chemical Analysis:
Fat and protein were determined in chicken breast meat and chicken burger formulas at zero time according to (AOAC, 2000).

Physical Analysis:

Cooking Loss Was Calculated As Follows:

\[
\text{Cooking loss %} = \frac{F-g}{F} \times 100
\]

F = Fresh burger sample weight
\( g \) = grilled burger sample weigh

b. Shrinkage percentage was calculated as described by AOAC (2000) as follows:

\[
\text{Shrinkage %} = \frac{(a-b)+ (c-d)}{a+c} \times 100
\]

a = Thickness of uncooked burger  c = Diameter of uncooked burger
Water Holding Capacity and Plasticity:

Water holding capacity and plasticity were measured using the method of Wierbicki and Deatherage (1958) as follows:

Minced meat sample (0.3 g) was placed on an ashless filter paper Whatman No. 41, between two glass plates and pressed for 10 minutes by one Kg weight. Two zones were formed on the filter paper (The outer zone resulted from the water separated from the pressed tissues and the internal zone due to the chicken meat pressed) and their surface areas were measured by a planimeter.

The water holding capacity was calculated by subtracting the area of the internal zone from that of the outer zone. Data were presented as cm².

Tenderness:

The Warner Bratzler shear force apparatus AmEtetek/Mansfield & Green div. Largo, Florida was used to measure the tenderness of cooked samples according to El-Nagar, (1999).

Samples were cooked and then cooled to room temperature, sheared for three times at different position and average of the shear force test was calculated in Newton (N).

Color:

Color of chicken burger samples was measured using a spectrophotometer Tristimulus color machine with the CIE Lab color scale (Hunter, Lab. Scan XE -Reston VA, USA) in the reflection mode Hunter (1958).

Organoleptic Analysis:

Cooked chicken burger samples were evaluated organoleptically, immediately after cooking (zero time) and at (45 and 90 days) of frozen storage at -20°C.

Sensory quality attributes include color, chewiness, taste, appearance; texture and overall acceptability were evaluated according to Gelman and Benjamin (1989).

Statistical Analysis:

The statistical analysis of the data of each attribute samples was carried out by analysis of variance (ANOVA one way) and least significant difference (L.S.D.) at 5% level of significance as reported by Snedecor and Cochran (1980).

RESULTS AND DISCUSSIONS

Our preliminary studies revealed that, the best percentage of using carrageenan, potato starch, carboxymethyl cellulose and maltodextrin as a fat replacers were (0.4, 2.5, 0.7, 0.7 %), respectively to produce low-fat chicken burger with highly scores of sensory evaluation.

The data showed that, using selected fat-replacers, reduced fat and protein content in chicken breast meat from 5.39 and 73.82% to 2.75 and 67.85% (dry weight basis) respectively in formulated samples with fat substituted.

Physical Analysis:

Data presented in Table (2) showed that cooking loss, shrinkage, water holding capacity (WHC) and shear force of low-fat chicken burger was affected by using fat replacers.

Results also indicated that cooking loss for all low fat chicken burger formulas ranged from 25.40-39.34% at zero time storage.

It can be noticed that, the LF₁ and LF₂ had lower cooking loss (30.0 and 25.40 %) than control sample and LF₄ (33.88 and 39.36 %) respectively. This indicated the effect of potato starch and carrageenan in reducing cooking loss which may be due to moisture retention through the product (Moghazy, 1999).

The same Table illustrated that extending storage time to 90 days at -20°C was accompanied by a gradual increase in cooking loss in the formulas during cooking (Abdel-Qader, 2004). Shrinkage is considered one of the important quality attributes of meat products. Results in Table (2) showed that shrinkage of all samples at zero time storage had lowest percentage than the control sample.

During storage, between zero and 90 days, shrinkage for all samples increase which was probably due to the higher loss in fat and moisture during cooking. Formulas containing carrageenan and potato starch had the less shrinkage. Samples contain Maltodextrin had the highest shrinkage which concurs the low WHC results and thus the diameter would be reduced to the high loss of moisture (Troy, 1999).

There was a significant difference in shear force values among all samples at zero time storage. Sample LF₃ was softer compared with other samples, whereas sample LF₁ was the hardest ones. These results show that fat
content has an inverse relationship to shear force, being less resistant to shear force compared to hard proteinaceous matrix such as the low fat formulas. At 90 days storage, addition of potato starch reduced shear force than other formulas; it was probably due to the ability of potato starch to hold water (Blackmer, 1992).

Water holding capacity results for grilled chicken burger were shown in table (2). Results indicated that water holding capacity for all samples ranged from 0.9 and 3.4 CMC/0.3 gm and increased in Chicken burger containing CMC and carrageenan due to their ability to absorb large amounts of water during cooking at zero time.

During storage, all low fat chicken burger had a lower WHC values, but similar to the control sample. The WHC seems to improve due to the addition of carrageenan and Maltodextrin in the formulas. Its greatest advantage is its ability to retain moisture (Huffman and Egbert, 1990).

Table 2: Physical Parameters of Low-Fat Chicken Burger Formulas*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Carrageenan LF₁</th>
<th>Potato starch LF₂</th>
<th>Carboxymethyl cellulose LF₃</th>
<th>Maltodextrin LF₄</th>
<th>Control LF₅</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>45</td>
<td>90</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>Cooking Loss%</td>
<td>30.0 ± 6</td>
<td>33.0 ± 2</td>
<td>32.5 ± 0.0</td>
<td>35.0 ± 0.25</td>
<td>30.0 ± 0.04</td>
</tr>
<tr>
<td>Shrinkage %</td>
<td>10.1 ± 8</td>
<td>12.5 ± 3</td>
<td>13.3 ± 0.3</td>
<td>16.2 ± 0.01</td>
<td>14.3 ± 0.04</td>
</tr>
<tr>
<td>Water Holding Capacity cm²/0.3gm</td>
<td>2.20 ± 0.25</td>
<td>1.80 ± 0.01</td>
<td>2.10 ± 0.02</td>
<td>0.90 ± 0.07</td>
<td>1.90 ± 0.27</td>
</tr>
<tr>
<td>Plasticity cm²/0.3gm</td>
<td>4.10 ± 0.13</td>
<td>4.70 ± 0.01</td>
<td>4.40 ± 0.08</td>
<td>7.00 ± 0.27</td>
<td>3.80 ± 0.60</td>
</tr>
<tr>
<td>Shearing Force (N)</td>
<td>3.49 ± 0.04</td>
<td>5.10 ± 0.31</td>
<td>6.30 ± 0.02</td>
<td>2.40 ± 0.25</td>
<td>4.62 ± 0.05</td>
</tr>
</tbody>
</table>

*Means of three determinations ± standard Deviation

Table 3: Hunter Color Parameters of Low-Fat Chicken Burger Formulas*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>LF₁ Control</th>
<th>LF₂ Carrageenan</th>
<th>LF₃ Potato starch</th>
<th>LF₄ Carboxymethyl methyl cellulose</th>
<th>LF₅ Maltodextrin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>45</td>
<td>90</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>L*</td>
<td>47.3 ± 0.03</td>
<td>53.1 ± 0.03</td>
<td>57.4 ± 0.03</td>
<td>60.8 ± 0.01</td>
<td>57.1 ± 0.03</td>
</tr>
<tr>
<td>a*</td>
<td>10.51 ± 0.01</td>
<td>8.99 ± 0.25</td>
<td>7.07 ± 0.03</td>
<td>2.52 ± 0.03</td>
<td>6.49 ± 0.36</td>
</tr>
<tr>
<td>b*</td>
<td>28.35 ± 0.03</td>
<td>31.0 ± 0.25</td>
<td>29.9 ± 0.01</td>
<td>20.0 ± 0.54</td>
<td>30.3 ± 0.54</td>
</tr>
</tbody>
</table>

*Means of these determination ± standard deviation

Table 3 illustrated the L*, a* and b* values of the samples at zero time and during storage. It showed that using potato starch as a fat replacer significantly increased lightness L* and decreased a* values than control sample at zero time.
The lowest $L^*$ value was found in Maltodextrin at 45.67 and highest $a^*$ values was 13.36. $L^*$ Value increased in Maltodextrin and control samples at the end of storage than other samples. While storage caused increase in $b^*$ in all samples. Some authors reported that lightness in meat and meat products depend on several factors such as water holding capacity (Fernandez et al., 2006) and fat content (Littinandana et al., 2005).

**Organoleptic Evaluation:**
Appearance and color are among the most important attributes influencing customer choice and texture also plays a relevant role on the perception of quality of eat and chicken products. Sensory characteristics of selected fat-replacer to produce desirable low-fat chicken burger are shown in Table 4.

Results in Table 4 indicated that cooked sample containing Maltodextrin and potato starch have the highest values for color, chewing, appearance, taste and overall acceptability among all other samples. On the other hand, formulas with CMC had lower scores in color, appearance and taste than other formulas. After 3 months storage samples (LF₅, LF₂ and LF₁) had significantly higher scores than those of the other formulas (LF₃ and LF₄).

These results indicated that among all burger tested those formulated with maltodextrin and potato starch are more healthy products based on their low fat.

**Table 4:** Statistical evaluation of the sensory characteristics of low fat chicken burger*.

<table>
<thead>
<tr>
<th>Properties</th>
<th>LF₁ Carrageenan</th>
<th>LF₂ Potato starch</th>
<th>LF₃ CMC</th>
<th>LF₄ Maltodextrin</th>
<th>LF₅ Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>45</td>
<td>90</td>
<td>45</td>
<td>90</td>
<td>45</td>
</tr>
<tr>
<td>Color</td>
<td>7.00±1.34</td>
<td>7.22±1.34</td>
<td>7.60±0.77</td>
<td>8.00±1.13</td>
<td>7.60±1.12</td>
</tr>
<tr>
<td>Chewing</td>
<td>6.77±1.79</td>
<td>5.90±2.34</td>
<td>7.71±0.17</td>
<td>7.00±1.26</td>
<td>5.60±2.19</td>
</tr>
<tr>
<td>Taste</td>
<td>7.14±1.34</td>
<td>7.77±1.26</td>
<td>6.50±2.34</td>
<td>6.57±1.11</td>
<td>5.60±1.34</td>
</tr>
<tr>
<td>Appearance</td>
<td>8.57±0.46</td>
<td>8.72±0.46</td>
<td>7.80±1.57</td>
<td>7.51±1.15</td>
<td>6.88±1.13</td>
</tr>
<tr>
<td>Texture</td>
<td>8.14±1.13</td>
<td>7.77±1.26</td>
<td>6.70±2.46</td>
<td>7.28±0.34</td>
<td>5.83±1.45</td>
</tr>
<tr>
<td>Overall acceptab</td>
<td>5.71±2.81</td>
<td>6.33±2.77</td>
<td>7.40±0.36</td>
<td>7.10±0.25</td>
<td>6.44±0.25</td>
</tr>
</tbody>
</table>
| *Means of three determination ± standard deviation

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