Effect of using tiger nuts (*Cyperus esculentus*) on nutritional and organoleptic characteristics of beef burger.

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The nutritional and organoleptic characteristics of low-fat beef burger manufactured with different levels of tiger nuts (*Cyperus esculentus*) as a partial fat substitute were studied. Chemical composition, cooking yield, pH and sensory evaluation were determined. Five levels of added beef fat (15%, 12.5%, 10%, 7.5%, and 5%) and five levels of tiger nuts (*Cyperus esculentus*) as a fat substitute (0%, 2.5%, 5%, 7.5%, and 10%) were used. Increasing the level of added tiger nuts caused an increase in fiber and ash contents, a decrease in fat content and no noticeable differences in protein content. Cooking yield increased by the increasing of tiger nuts level. The sensory evaluation had done by trained panelists and they scored for taste, odor, texture, and color. The sensory properties and overall acceptability were improved by using 5% and 7.5% of tiger nuts and no differences noticed between the overall acceptability of the control treatment and other treatments. On another hand, the caloric value was also decreased by decreasing of added fat and replacing it with tiger nuts which have low caloric content when compared with animal fat.

Keywords: Low Fat, Beef Burger, Tiger Nuts, Dietary Fibers

INTRODUCTION

Fat is one of the main food ingredients, which influences the organoleptic characteristics of meat products. However, extreme consumption of fat contributes to obesity, arteriosclerosis and colon cancer (De Vries, 2007). Generally, traditional meat products contain up to 30% fat (Woo et al., 1995). The fat plays important roles in meat product processing such as, stabilizing meat emulsions, reducing cooking loss, improving water holding capacity and providing flavor, juiciness, and desirable mouth feel. However, animal fat provides high amounts of saturated fatty acids and cholesterol (Ozvural and Vural, 2008; Pappa, et al., 2000). So that High animal fat intake is associated with obesity, hypertension, cardiovascular diseases and coronary heart diseases (Moon et al., 2008). Hence, the reduction of fat in meat products and the substitution of animal fat with vegetable oils and non-meat ingredients such as dietary fiber, isolated soy protein, and carrageenan should result in healthier products. Following increased consumers demand for fast food such as beef burger, many efforts have been made to improve the quality and stability of burgers (Besbes et al., 2008; Sanchez-Zapata et al., 2010). In burgers, quality deterioration is often caused by oxidation reactions and the subsequent decomposition of oxidation products during storage. The presence of high amount of animal fat in beef burger increases the chance of accelerating lipid
oxidation, which subsequently increases the number of lipid hydroperoxides, leading to decreased shelf life (Kerler and Grosch, 1986). The development of lipid oxidation in meat products during their processing, distribution and storage adversely affects critical quality attributes such as flavor, color and nutritional value and has a major negative economic impact (McBride et al., 2007). For several years now, the use of natural antioxidants in foods has been increasing as a result of consumer demand. Consumers are becoming more health conscious and concerned about what ingredients are added to their foods. Natural products are perceived as safer and healthier than synthetic ones (Ahn et al., 2002; Johnston et al., 2005).

One of these natural products which can be used to substitute animal fat and improve the quality and shelf life meat products is tiger nuts (Cyperus esculentus). It’s a weed plant of tropical and Mediterranean regions. It is a root crop which grows widely in wet places as a grass and is sometimes cultivated for its small and sweet tubers (Etchesola and Oraedu, 1996). It’s commonly known as yellow nut-grass or chufa flat sedge belongs to the Cyperaceae family, it is a perennial herb from slender, scaly rhizomes ending with hard, greyish, and orange to dark tubers that grows to heights between 24 and 55 cm (Swift, 1989). Other types of tiger nuts exist. For example, there are two types of variety which have been identified in the USA; the cultivated (yellow nut’sedge) and the wild (purple nut’sedge). The stems are three-sided and triangular in cross-section while the leaves are yellow to green in colour with a distinct ridge. Its fibrous roots originate from the tubers, rhizomes, and basal bulbs (Defelice, 2002 and Parker et al., 2000).

It is the only known tuber or root plant as affirmed by Manek et al. (2012) that produces underground storage organs containing a significant amount of all three storage reserves: starch, sucrose and oil, as compared to other known plants belonging to roots and tubers that normally accumulate high amount of starch or sugars in their roots or tubers tissues. Tiger nuts is very famous in Egypt and locally named (hab al-aziz), where it is mainly consumed after soaked in water for tenderization or blanched as a traditional snack food and or roasted and grinded in powder form as a drink. The oil from the nut is extracted by traditional methods on a small scale for food uses. Zohary and Hoff (2000), consider tiger nuts tuber as being rank among the oldest cultivated plants in ancient Egypt. The cultivation of tiger nuts originates from ancient Egypt. According to Darby et al., (1977), the nuts have been found in archaeological sites. From Egypt, the Arabs merchants helped to spread its cultivation North and West of Africa, and Sicily. Tiger nut is known also in other parts of the world, especially in the Valencia region of Spain where it is commonly known as “chufa” and the oil from the nut is now produced on a commercial scale for the European market (Yeboah et al., 2012). Tiger nuts contain substantial amounts of lipids; and the oil is used in cooking as well as a cosmetic ingredient. The nuts are also a good source of carbohydrates and fibers. Despite its rich nutritional values, it is relatively less explored as a food when compared to other edible nuts and tubers. Nowadays, the tiger nuts processing has received much attention among food industries due to its increasing popularity among Mediterranean consumers (Martin-Esparza and Gonzalez-Martinez, 2016).

Several reports have revealed that the extracts or by-products of tiger nuts exhibit antioxidant activity (Badejo et al., 2014, Sánchez-Zapata et al., 2012); which is ascribed to its polyphenol contents. However, diversity of antioxidant compounds present in tiger nuts has not been thoroughly explored. Nevertheless, a number of investigations have shown the development of attractive food products from tiger nuts. In figure (1 and 2) the tiger nuts plant, tubers and its flour.

Tiger nuts have been used medically by the ancient Egyptians for these purposes: mouth cleaning, ophthalmic, ointment, wound dressings, fumigation, to sweeten the smells of houses and clothes, together with myrrh incense (Defelice, 2002). In modern Egypt, El-Shebini et al., (2010) have reported that daily consumption of raw tiger nuts (30g) has been shown to contribute to effective weight loss and improvement of the metabolic disorders among obese diabetic patients. Ejoh et al., (2006) have proposed that food formulas can be developed by fortifying it with the flour of tiger nuts as a result of its high nutritional contents.

So that, the main objective of this research was studying the possibility of using different concentrations of tiger nuts as a partial fat substitute and studying the effect of that on the chemical, nutritional and sensory characteristics of beef burger.
MATERIALS AND METHODS

The study was conducted in Russian Federation at the Department of Technology and biotechnology of food products of animal origin, Moscow state university of food production (MGUPP).

Materials:
Tiger nuts (Cyperus esculentus) was obtained from the local market in Egypt and It was washed and sorted and then been well crushed to get a flour which will be then used in the manufacture of the beef burgers, taking into account that milling and preparing operations should be done before manufacturing directly due to a large amount of fat in tiger nuts. fresh lean beef and other additives (soy flour, skimmed milk, spices mixture and salt) were obtained from the local market in Moscow, Russian Federation. Lean beef cuts were obtained from boneless rounds and trimmed from all subcutaneous and intermuscular fat as well as thick and visible connective tissue.

Methods:
Formulation of beef burger: The lean meat and fat were separately ground in a meat grinder. The fat content of the lean meat and fat was determined prior to the manufacture of burgers. The lean meat contained (4% fat) and beef fat
contained (89 % ether extract), five treatments were formulated according to (Table 1). The control burgers were formulated to contain 65% lean meat and 15% beef fat. Different levels of tiger nuts (2.5 %, 5.0 %, 7.5 % and 10.0%) were used to replace equal amounts of added beef fat. Appropriate amounts of each formulation were mixed by hand, subjected to final grinding (0.5 cm plate) and processed into burgers (60 g weight and 10 cm diameter). Burgers were placed on plastic foam trays, wrapped with polyethylene film and kept frozen at -18°C until further analysis.

Chemical composition
Moisture, ash, crude protein, fat and crude fiber contents were determined according to the methods described in the AOAC (2000) methods.

Caloric values:
Total calorie (Kcal) for uncooked burgers were calculated on the basis of 100 g sample using the next values for fat (9 Kcal/g), protein (4.02 Kcal/g) and carbohydrates (3.87 Kcal/g) as described by Mansour and Khalil (1997).

Physicochemical Properties:
The pH values of beef burger samples were measured by homogenizing 10gm of sample with 100 ml of distilled water for 30 sec. The pH of the prepared sample was measured using a pH meter (Jenway 3510 pH meter) at 20 ºC according to the method described by Fernández-López et al. (2006).

Cooking procedure:
Frozen burgers were cooked in a preheated (148ºC) electric grill which was standardized for temperature. The burgers were cooked for 6 minutes, then turned and cooked 4 minutes on the other side. The burgers were weighed before and after cooking to determine percentage cooking yield according to Ali et al., (2011) as follows:
Cooking yield (%) = (Weight of cooked burger/Weight of uncooked burger) × 100

Sensory evaluation:
Sensory evaluation of cooked burgers was performed according to Watts et al. (1989). Five burgers from each formulation were cooked as previously described, and maintained warm in an oven until testing within 3–8 min. (10) Experienced panelists were recruited from the staff and students from the Department of Technology and biotechnology of food products of animal origin, Moscow State University of Food Production, Moscow, Russian Federation. Panelists were chosen on the basis of previous experience in consuming traditional burgers. Furthermore, a preparatory session was held prior to testing, so that each panel could thoroughly discuss and clarify each attribute to be evaluated in burger. Rectangular pieces approximately (1.5:2 cm) were cut from the center of burgers, and were served at room temperature. Each panelist evaluated three replicates of all formulas; the sample presentation order was randomized for each panelist. Tap water was provided between samples to cleanse the palate. Panelists were asked to evaluate different treatments and requested to score their quality attributes: color, odor, taste, texture and overall acceptability on a 10 points scale was used for each factor as follows.
9-10= Excellent 7-8= Very good
5-6 = Good 3-4 = Not good
1-2 = very bad

Table (1): Beef burger formulation containing Tiger nut (Cyperus esculentus)

<table>
<thead>
<tr>
<th>Components</th>
<th>Control</th>
<th>T1 (2.5%)</th>
<th>T2 (5%)</th>
<th>T3 (7.5%)</th>
<th>T4 (10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lean meat</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Beef fat</td>
<td>15</td>
<td>12.5</td>
<td>10</td>
<td>7.5</td>
<td>5</td>
</tr>
<tr>
<td>Tiger nut</td>
<td>-</td>
<td>2.5</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
</tr>
<tr>
<td>Soy flour</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Onion</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Salt</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Skimmed milk</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Spices mixture</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Starch</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Control: treatment without Tiger nut, T1: treatment 1 (2.5% Tiger nut), T2: treatment 2 (5% Tiger nut), T3: treatment 3 (7.5% Tiger nut) and T4: treatment 4 (10% Tiger nut)
RESULTS AND DISCUSSION

The proximate chemical composition of tiger nuts:

Data in Table (2) shows the proximate composition of tiger nut’s tubers (g/100g) compared to some of other nuts. It could be observed that tiger nut’s lipid, protein and carbohydrate contents are higher than those in other tubers which contain mainly carbohydrates. However, if tiger nuts is compared to real nuts, it is observed that the fiber content is within the usual range for nuts, but the moisture and carbohydrate contents are much higher and the lipid and protein contents are lower than in real nuts. In general tubers have a high content of carbohydrate, their profile and relative contents decreases and the reducing sugar contents increases during storage (Coskuner et al., 2002).

According to Sanchez-Zapata et al., (2009), tiger nut oil have the following free fatty acids; 14:0 (0.2%), 18:0 (3.2%), 20:0 (0.4%), 16:1 n-7 (0.3%), 18:1 n-9 (72.6%), 18:2 n-6 (8.9%) and 18:3 n-3 (0.4%). In a research carried out by Dubois et al. (2007) on some vegetable oils, they asserted that tiger nut oil has a monounsaturated profile (>60%).

Manek et al., (2012) have found that tiger nuts (Cyperus esculentus) starch is a brilliant white, odorless powder with a warm bland taste and smooth texture. Tiger nuts starch exhibits elliptical to spherical granules with a relatively smooth surface. Scanning electron microscopy indicates that tiger nuts (Cyperus esculentus) starch has uniform granular size, shape, and morphology. Size distribution of a potential excipient has been shown to affect various formulation characteristics like flowability, compactibility, water binding capacity, and drug release (Li et al., 2004).

Chemical composition of burgers formulas:
The chemical composition of beef burgers is presented in Table (3). The difference in the composition of the different treatments is attributed only to the added amount of tiger nuts because the main recipe of treatments was the same. Moisture content was not affected by the substitution of fat with tiger nuts flour because they have similar moisture content. The presence of tiger nuts increased slightly the protein content than the control sample. Whoever, this increasing was not noticeable when the highest protein content (15.54%) was recorded for treatment 4 (10 % tiger nuts). fiber content was increased depending on the increasing of added tiger nut and this is due to the considerable fiber content of tiger nuts. Substitution of fat with tiger nuts flour caused a decrease in fat content and caloric value of beef burger. The fat content ranged from 17.61% in control treatment to 10.81% in treatment 4 (10 % tiger nuts). And caloric value decreased from 228.99 to 184.64 Kcal/100g.

Cooking characteristics and Physicochemical Properties

The pH value is considered an important characteristic because of its influence on shelf-life, color, water holding capacity and texture of meat and meat products (Clarke et al., 1988). Data in Table (4) shows that pH value was decreased because of adding tiger nut. Cooking loss percent was decreased and cooking yield percent was increased by increasing the concentration of added tiger nuts. These results confirmed that addition of tiger nuts improves the quality attributes of beef burger.

<table>
<thead>
<tr>
<th>Table (2): proximate composition of tiger nut tubers (g/100g) compared to some of other nuts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
</tr>
<tr>
<td>Tiger nut</td>
</tr>
<tr>
<td>Almonds</td>
</tr>
<tr>
<td>Hazelnuts</td>
</tr>
<tr>
<td>Walnuts</td>
</tr>
<tr>
<td>Peanuts</td>
</tr>
</tbody>
</table>
Table (3): Chemical composition of burgers formulas prepared with different concentrations of tiger nuts (g/100 g wet basis)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moisture</th>
<th>Protein</th>
<th>Fat</th>
<th>Ash</th>
<th>Fiber</th>
<th>Carbohydrates</th>
<th>Energy Kcal/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>61.20</td>
<td>15.17</td>
<td>17.61</td>
<td>2.12</td>
<td>1.44</td>
<td>2.46</td>
<td>228.99</td>
</tr>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt; (2.5%)</td>
<td>61.43</td>
<td>15.27</td>
<td>15.87</td>
<td>2.18</td>
<td>1.83</td>
<td>3.42</td>
<td>217.45</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt; (5%)</td>
<td>61.53</td>
<td>15.35</td>
<td>14.24</td>
<td>2.22</td>
<td>2.25</td>
<td>4.41</td>
<td>206.93</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt; (7.5%)</td>
<td>61.57</td>
<td>15.49</td>
<td>12.60</td>
<td>2.31</td>
<td>2.61</td>
<td>5.42</td>
<td>196.64</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt; (10%)</td>
<td>61.94</td>
<td>15.54</td>
<td>10.81</td>
<td>2.38</td>
<td>2.90</td>
<td>6.43</td>
<td>184.64</td>
</tr>
</tbody>
</table>

Control: treatment without Tiger nut, T<sub>1</sub>: treatment 1 (2.5% Tiger nut), T<sub>2</sub>: treatment 2 (5% Tiger nut), T<sub>3</sub>: treatment 3 (7.5% Tiger nut) and T<sub>4</sub>: treatment 4 (10% Tiger nut).

Table (4): Effect of substituting fat with various levels of tiger nut on pH, and cooking yield of beef burger.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cooking Yield %</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>74.94 ± 0.01</td>
<td>6.26 ± 0.01</td>
</tr>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt; (2.5%)</td>
<td>78.75 ± 0.05</td>
<td>6.19 ± 0.01</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt; (5%)</td>
<td>79.19 ± 0.01</td>
<td>6.11 ± 0.01</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt; (7.5%)</td>
<td>82.58 ± 0.01</td>
<td>6.09 ± 0.04</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt; (10%)</td>
<td>83.77 ± 0.03</td>
<td>5.98 ± 0.02</td>
</tr>
</tbody>
</table>

Control: treatment without Tiger nut, T<sub>1</sub>: treatment 1 (2.5% Tiger nut), T<sub>2</sub>: treatment 2 (5% Tiger nut), T<sub>3</sub>: treatment 3 (7.5% Tiger nut) and T<sub>4</sub>: treatment 4 (10% Tiger nut).

Values are means of triplicate ± standard division

Table (5): Effect of replacing fat with various levels of tiger nut on sensory properties of cooked beef patties

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Taste</th>
<th>Odor</th>
<th>Color</th>
<th>Texture</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>8.5</td>
<td>8.5</td>
<td>8.4</td>
<td>8.7</td>
<td>8.8</td>
</tr>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt; (2.5%)</td>
<td>8.7</td>
<td>8.5</td>
<td>8.5</td>
<td>8.8</td>
<td>9.0</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt; (5%)</td>
<td>8.6</td>
<td>8.6</td>
<td>8.5</td>
<td>8.7</td>
<td>9.0</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt; (7.5%)</td>
<td>8.6</td>
<td>8.5</td>
<td>8.3</td>
<td>8.6</td>
<td>8.8</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt; (10%)</td>
<td>8.3</td>
<td>8.2</td>
<td>8.0</td>
<td>8.2</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Control: treatment without Tiger nut, T<sub>1</sub>: treatment 1 (2.5% Tiger nut), T<sub>2</sub>: treatment 2 (5% Tiger nut), T<sub>3</sub>: treatment 3 (7.5% Tiger nut) and T<sub>4</sub>: treatment 4 (10% Tiger nut)

Sensory evaluation

As in all food products, organoleptic tests are generally the final guide to the quality from the consumer's point of view. Organoleptic evaluation was carried out in order to evaluate the taste, odor, color, texture and overall acceptability of beef burger affected by different concentrations of tiger nuts. Data in table (5) shows that there was a significant difference in taste between control samples and samples prepared with 2.5% tiger nuts and this treatment had a score higher than the control treatment at the same time there weren't significant differences between the control treatment and the 5% tiger nuts treatment. About the odor parameter, there weren't any significant differences between the control treatment and other treatments unless 10% tiger nuts treatment. Color and texture also were evaluated by the panelists and there weren't any significant differences between the control treatment and (2.5%, 5%) tiger nuts treatments where there were significant differences among the control treatment and (7.5%, 10%) tiger nut treatments. In General, there weren't any significant differences among the control treatment and other treatments in the overall acceptability unless the last treatment 10% tiger nut it had the minimum
score by the team of panelists.

CONCLUSION

The use of tiger nuts has a prospective effect as a functional ingredient to develop the cooking properties of the beef burger. As well as increasing the water holding capacity. Addition of tiger nuts increased the fiber content which is an additional nutritional benefit for the consumers if an increase in dietary fiber is normally recommended. In addition, decreasing the fat level will help to reduce the risk of heart disease and obesity. Tiger nuts may be attractive to some meat producers as a positive cheap alternative to conventional fillers in meat products.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study.

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