

PHYSICOCHEMICAL, QUALITY CHARACTERISTICS AND MICROBIOLOGICAL EVALUATION OF FROZEN AND CHILLED BEEF BURGER

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ABSTRACT

The present study was planned to compare between frozen and chilled beef burgers. A total of 60 random samples of frozen and chilled beef burgers (30 of each) were collected during the period from May to August 2022 from different supermarkets for frozen beef burgers and refrigerators of markets for chilled beef burgers from Assiut City, Egypt. The samples were investigated for their sensory assessment, microbiological evaluation, physicochemical and keeping quality. To determine whether the results were acceptable, they were compared to Egyptian standards. The results showed that the frozen samples had lower scores of sensory evaluations, but higher in other tests than the chilled samples. Regarding chemical composition, no significant differences between mean values of moisture, fat and ash% of both frozen and chilled samples. The mean values of protein% of chilled samples were higher (15.72 ± 0.66) than frozen samples (12.96 ± 0.52), while the mean values of carbohydrate% were lower. Higher pH and phosphate values (6.39 ± 0.028 and 0.373 ± 39.28) in frozen samples in comparison with chilled samples (5.89 ± 0.03 and 0.192 ± 20.64). The obtained mean values of TBA (mg/kg) were 0.46 ± 0.07 and 0.53 ± 0.08 mg/kg, while TVBN were 12.16 ± 0.64 and 11.93 ± 1.25 % in frozen and chilled samples, respectively. This study indicated defective manufacturing and storage in some chilled and frozen beef burger samples that aren't of adequate hygienic quality and don't meet Egyptian requirements. It is important to consider the potential public health risks associated with increased phosphorus (food additive) intake through additions. Regular monitoring and evaluations by researchers should be done for these chemicals.

Keywords: Meat products, Sensory, Microbial, Nutritional aspects, keeping quality.

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INTRODUCTION

Beef burger patties are among the most well-liked meat items in the fast-food industry (Clonan *et al.*, 2016). Many factors contributed to the consumption of beef burger patties, including the influence of the advertising industry, globalization, shorter meal preparation times, and increased consumer demand for practical goods that are easily accessible and simple to make (Ramos *et al.*, 2021). Fresh minced beef is a common ingredient in many meal preparations all over the world, particularly for burger patty recipes. To prevent bacterial deterioration, minced beef needs to be frozen or refrigerated as soon as it is purchased. Even if the meat is promptly packaged and cooled, the grinding process results in the leakage of tissue fluids, which serve as a rich nutritional source for a variety of bacteria and promote rapid microbial growth. Large amounts of animal fat in meat products speed up the oxidation of lipids, resulting in a shorter shelf life. As a result, the oxidation of lipids during processing and storage affects crucial quality traits like flavor, color, and nutritional value in meat products (Baoumy and Abdelmaksoud, 2021). Fresh or frozen skeletal muscles and the fatty tissue that accompanies them are used to make minced meat. As a result of the irreversible loss of the muscle tissue's cellular structure during the mincing process, minced meat turns into a product that is both incredibly nutritive and perishable. Such a product is susceptible to rapid bacterial growth due to the redistribution of surface contamination across the entire mass. The maximum storage time for raw meat from the moment of slaughter till the time of mincing is still an open issue for the meat industry (EFSA, 3783/2014). Yeast and

mold are two examples of the many common microorganisms. Since it increases the likelihood of spoilage and degradation, resulting in significant financial losses and posing a public health threat due to the creation of a wide range of mycotoxins, contamination of meat products with various yeast and mold species is considered to be a real risk (Abd El-Wahab *et al.*, 2021). The goal of the current investigation was to evaluate the physical, chemical, microbiological, and sensory characteristics of beef burgers stored in chilled and frozen conditions.

MATERIALS AND METHODS

1. Collection of Samples:

A total of 60 random samples of frozen and chilled beef burgers (30 of each) were collected during the period from May to August 2022 from local and highly different retail markets of Assiut City, Egypt, for (frozen beef burgers) and refrigerators of markets and butchers for (chilled beef burger). Samples were collected and prepared in areas free from air currents on work surfaces that have been cleaned and sanitized assuring that no foreign sources of microbial contamination were introduced. Sample equipment was sterilized before usage, and it was kept safe from external contamination while in use. Then samples were placed into sterilized containers and placed in refrigerators or freezers. Frozen and chilled samples were transferred immediately with a minimum period of delay to the laboratory in an ice bag. Samples are identified by number and production/sample date. It is recommended that ground beef patties be evaluated within 3 months of frozen storage (AMSA, 2015).

2. Sensory Evaluation:

The analysis was performed according to (ISO 6658: 1985) and (AMSA, 2015). The test was performed for the different frozen and chilled cooked beef burger samples were assessed by 10-14 members of the Food Hygiene Department (with past experience in burger processing and evaluation) with randomly coded numbers and served warm to panelists to evaluate their sensory characteristics for color, odor, texture (juiciness and appearance), and overall acceptability. A 5-point hedonic scale measuring general acceptability is used, with one denoting "dislike extremely" and five denoting "like extremely."

3. Physical examination:

3.1. Water holding capacity (WHC): was determined by filter press method as described by Honikel (1998).

3.2. Cooking properties:

Beef patties were cooked on an electrical grill for 7 min for each side until the internal temperature reached 73°C (Serdaroğlu *et al.*, 2018).

3.2.1. Shrinkage%: were determined before and after cooking according to the method of ((Bakhsh *et al.*, 2021) with the following formula:

$$\text{Shrinkage (\%)} = \frac{[\text{raw burger diameter (mm)} - \text{cooked burger diameter (mm)}]}{\text{raw burger diameter (mm)}} \times 100$$

3.2.2. Cooking loss (%): Beef burgers were weighed before and after cooking to determine the cooking loss (CL %) using a method described by (Bakhsh *et al.*, 2021) by using the following equations:

$$\text{Cooking Loss (\%)} = \frac{[\text{raw weight (g)} - \text{cooked weight (g)}]}{\text{raw weight (g)}} \times 100$$

3.2.3. Cooking yield: The cooking yield of the beef burgers was determined by the method described by (Gök *et al.*, 2011) and calculating weight differences for burgers before and after cooking, as follows:

$$\text{Cooking yield (\%)} = \frac{\text{Cooked weight (g)}}{\text{Raw weight (g)}} \times 100$$

4. Chemical composition:

Moisture, fat (ether extractable), ash content were estimated in duplicate using the official methods of the Association of Official Analytical Chemists (AOAC, 2018). Crude protein% was determined by "Biuret method" (Reichardt and Eckert, 1991). While total carbohydrate was estimated by difference according to (AOAC, 2000) using the following equation:

$$\begin{aligned} \text{Total carbohydrate} \\ = 100 - (\text{moisture\%} + \text{protein\%} \\ + \text{fat\%} + \text{ash\%}) \end{aligned}$$

The gross energy content of beef burger was calculated according to (Merrill and Watt, 1973) by the following equation:

$$\begin{aligned} \text{Gross energy value (kcal/100g)} = \\ (\text{Protein\%} \times 4) + (\text{Fat\%} \times 9) + \\ (\text{Carbohydrate\%} \times 4). \end{aligned}$$

5. Keeping quality characteristics:

5.1. Determination of pH value (Assanti *et al.*, 2021):

The pH was obtained at 25°C at the time of calibration, and before measured solutions the pH meter was calibrated with standardized buffer solution at pH 7.0 and pH 4.0, with a portable pH meter (Adwa, Waterproof PH Testers AD11, Romania).

5.2. Total Volatile Nitrogen (TVN) determination in accordance with (EOS 639/2006).

5.3. Thiobarbituric acid reactive substances (TBARS) values were determined according to Radha *et al.* (2014).

5.4. Phosphorus content was estimated according to (ISO, 1996 and 1998).

6. Microbiological examination:

The burgers were subjected to microbiological analysis, aiming to identify the main bacteria in the frozen and chilled beef burgers.

6.1. Determination of Total bacterial count (TBC) in accordance with (ISO 4833:2013-1 protocol).

6.2. Determination of Total psychotropic count (TPsC) in accordance with (ISO 4833:2013-1 protocol).

6.3. Determination of Total Yeast and molds was performed using Sabouraud dextrose agar (SDA) supplemented with (Chloramphenicol and Gentamicin) and incubated for 5 days at 28 °C and data were presented as log₁₀cfu/g in accordance to (ISO 21527-2:2008).

7. Statistical Analysis

Graph Pad Prism version 8.0.2 (263) software was used to conduct the statistical analysis. T-test analysis was used to analyze all of the results. To find significant differences, an unpaired t-test was run with a significance level of $p < 0.05$ (one-tailed P value). The gathered information was presented as mean \pm SE. Trials and measurements were carried out in duplicate.

RESULTS

Table 1: Sensory evaluation for frozen and chilled beef burger samples (30 of each).

Groups of burger samples	Frozen burger	Chilled burger	P value
Appearance	3.07 \pm 0.17	3.30 \pm 0.23	0.2106
Odor	2.90 \pm 0.21	3.20 \pm 0.23	0.1684
Taste	2.70 \pm 0.19	2.77 \pm 0.22	0.4110
Texture	3.70 \pm 0.21	3.20 \pm 0.19	0.0321*
Mastication	2.80 \pm 0.22	2.97 \pm 0.20	0.2921
Overall Acceptance	2.37 \pm 0.17	3.10 \pm 0.22	0.0060**

Consumer acceptability scores on a 5-point hedonic scale:

(1-dislike extremely; 2-dislike slightly; 3-neither like nor dislike; 4-like slightly; 5-like extremely).

The significant difference between the mean of texture and overall Acceptance.

Table 2: Physical examination of frozen and chilled beef burger samples (30 of each):

Groups of burger samples	Frozen burger	Chilled burger	P value
WHC	19.27 ± 0.9	22.74 ± 1.26	0.0144 *
Shrinkage (%)	12.18 ± 0.82	21.41 ± 1.56	<0.0001****
Cooking loss (%)	13.54 ± 1.15	26.27 ± 1.68	<0.0001****
Cooking yield (%)	84.66 ± 1.6	72.77 ± 1.8	<0.0001****

Significant difference among means.

Table 3: Chemical composition (%) of frozen and chilled beef burger samples (30 of each).

Groups of burger samples	Frozen burger				Chilled burger				P value
	Mean	Accepted	Not accepted	E.S	Mean	Accepted	Not accepted	E.S	
Moisture (%)	60.73±0.66	19 (63.3%)	11 (36.6%)	Not more than 60%	61.43 ±1.16	18 (60%)	12 (40%)	Not more than 60%	0.3011
Protein (%)	12.96±0.52	11 (36.6%)	19 (63.3%)	Not less than 15%	15.72 ±0.66	19 (63.3%)	11 (36.6%)	Not less than 15%	0.0009***
Fat (%)	10.86±0.86	28 (93.4%)	2 (6.6%)	Not more than 20%	12.60 ±1.19	26 (86.7%)	4 (13.3%)	Not more than 20%	0.1214
Carbohydrate (%)	12.55±0.58	16 (54%)	14 (46%)	Not more than 10%	7.27±0.66	(100%)	Not accepted (0%)	Not more than 10%	<0.0001****
Dry matter (%)	Mean 39.27 ± 0.7				Mean 38.43 ± 1.18				0.2671
Ash (%)	Mean 2.89±0.08				Mean 2.85±0.13				0.3945
Energy (Kcal/100g)	Mean 198.9±6.69				Mean 205.2±10.23				0.3037

***Significant difference between mean of protein and carbohydrate (%).

E.S = Egyptian Standards (E.S, 1688/2005).

Table 4: Keeping quality characteristics of frozen and chilled beef burger samples (30 of each).

Groups of burger samples	Frozen burger				Chilled burger				P value
pH	Mean 6.39 ±0.02	Accepted 14 (46.7%)	Not accepted 16 (53.3%)	E.S² 5.6-6.2	Mean 5.89± 0.03	Accepted (100%)	Not accepted (0%)	E.S¹ 6	<0.0001 ****
TBA (mg MDA /kg)	Mean 0.46±0.07	Accepted 26 (86.7%)	Not accepted 4 (13.3%)	E.S^{1,2} Not more than 0.9 mg MDA / Kg.	Mean 0.53± 0.08	Accepted 25 (83.4%)	Not accepted 5(16.6%)	E.S^{1,2} Not more than 0.9 mg MDA / Kg.	0.2617
TVB-N	Mean 12.16±0. 64	Accepted 30 (100%)	Not accepted (0%)	E.S^{1,2} Not more than 20 mg N/100g	Mean 11.93± 1.25	Accepted 26 (86.7%)	Not accepted 4 (13.3%)	E.S^{1,2} Not more than 20 mg N/100g	0.4359
Additive phosphate	Mean 373.7± 39.28	Accepted 14 (46.7%)	Not accepted 16 (53.3%)	E.S³ Not more than 0.3%	Mean 192.6± 20.64	Accepted (100%)	Not accepted (0%)	E.S -	0.0002 ***

***Significant difference between mean pH values and additive phosphate.

No Significant difference among means of TBA (mg MDA /kg), TVB-N.

¹Chilled meat (ES: 3602 /2013)

²Frozen meat (ES: 1522 -2005)

³Frozen Beef Burger (E.S, 1688/2005)

Table 5: Microbiological examination of frozen and chilled beef burger samples (30 of each).

Groups of burger samples	Frozen burger				Chilled burger				P value
Total bacterial count (log₁₀cfu/g)	Mean 5.04 ± 4.65	Accepted 23 (76.7%)	Not accepted 7(23.3%)	E.S Not more than 10 ⁵	Mean 4.62 ± 4.01	Accepted 26 (86.7%)	Not accepted 4 (13.3%)	E.S Not more than 10 ⁵	0.0701
Total psychotropic count (log₁₀cfu/g)	Mean 3.58 ± 3.34				Mean 3.82 ±3.54				0.2543
Total yeast and mold count (log₁₀cfu/g)***	Mean 3.39 ± 2.75				Mean 3.85 ± 3.05				0.0003

*** Significantly different among means of total yeast and mold count (log₁₀cfu/g)

(P < 0.05).

No Significant difference among means of total bacterial count and total psychotropic count (log₁₀cfu/g).

(P > 0.05)

E.S = Egyptian Standards (E.S, 1688/2005).

DISCUSSION

1. Sensory evaluation:

Many customers continue to base food safety on colour, despite the fact that the internal color of meat is an ineffective indicator of its safety (Suman *et al.*, 2016). The results in Table 1 demonstrated that frozen samples scored less favorably than chilled samples.

Texture and overall acceptance showed a significant difference ($p < 0.05$), although means of appearance, odor, taste, and mastication showed no significant change ($p > 0.05$).

For appearance, smell, taste, texture, and mastication in frozen beef burger samples, the corresponding mean values were 3.07 ± 0.17 , 2.90 ± 0.21 , 2.70 ± 0.19 , 3.70 ± 0.21 , and 2.80 ± 0.22 .

In contrast, the attributes of the chilled beef burger samples were 3.30 ± 0.23 , 3.20 ± 0.23 , 2.77 ± 0.22 , 3.20 ± 0.19 and 2.97 ± 0.20 , respectively. While chilled samples scored "moderately liked" with a mean of 3.10 ± 0.22 , which indicates good acceptance of the chilled beef burger samples. Frozen samples showed a slight reduction in the overall acceptability score (2.37 ± 0.17). On average, extra ingredients are added to items in order to influence their quality, shelf life, general acceptance, and the physicochemical reactions that take place when they are frozen (Da-Wen, 2006).

2. The physical examination of beef burger samples (frozen and chilled).

The Cooking properties of frozen and chilled beef burger samples are shown in Table 2.

2.1. WHC of beef burger samples:

The ability of meat to hold onto its own or provide water quickly throughout

processing is referred to as the water-holding capacity (WHC) of meat (Mona *et al.*, 2021). There was a significant difference between the means of frozen and chilled samples. The mean WHC% values for the frozen and chilled beef burger samples were 19.27 ± 0.9 and 22.74 ± 1.26 , respectively. Proteins that are denatured during freezing have lower WHCs (Augustynska-Prejsnar *et al.*, 2019; Utrera *et al.*, 2014).

2.2. Shrinkage (%) of beef burger samples:

Cooking shrinkage has been linked mostly to meat protein denaturation, which releases water and fat from the beef batter (Pathare and Roskilly, 2016). Shrinkage% increase in chilled beef burgers. Significant difference among means of shrinkage% ($P > 0.05$). The mean values were " 12.18 ± 0.82 " in frozen beef burger samples, while chilled samples were " 21.41 ± 1.56 ".

2.3. Cooking loss (%) of beef burger samples:

The moisture lost during the heating of the product up to a standard core temperature is known as cooking loss (CL) (Godschalk-Broers *et al.*, 2022). Regarding cooking loss (%) of frozen and chilled beef burger samples, highly significant differences among means ($P < 0.05$), the mean values were 13.54 ± 1.15 , and 26.27 ± 1.68 in frozen and chilled beef burger samples, respectively.

2.4 Cooking yield (%) of beef burger samples:

According to Aleson Carbonell *et al.* (2005), yield in meat and meat products is linked to fat and water retention. The mean values of cooking yield % were $(84.66 \pm 1.6$ and 72.77 ± 1.8 in frozen and chilled beef burger samples, respectively. A significant difference between means of

cooking yield % at both frozen and chilled samples,

5. Chemical composition (%):

When choosing meat products, consumers must have access to precise information on the chemical and nutritional contents (Erwanto *et al.*, 2012). The nutritional characteristics of the examined meat products are revealed by chemical analysis, and these characteristics are crucial for consumer health and acceptability (Ali *et al.*, 2020). Table 3 revealed the chemical composition % of samples of chilled and frozen beef burgers.

5.1. Moisture Content:

Obtained data revealed that the mean moisture contents of chilled and frozen samples, were 61.43 ± 1.16 and $60.73 \pm 0.66\%$, respectively. There were no significant differences between the chilled and frozen beef burger samples. These results were similar to those found in the beef burger by Ali *et al.* (2020), "61.02," and by Edris *et al.* (2012), " 61.28 ± 0.17 ."

Because Egypt has its own statutory nutritional standards for meat products, the samples were compared to those standards (E.S, 1688/2005), to determine how acceptably they met those standards. 11 (36.6%) of the frozen samples and 12 (40%) of the chilled samples exceeded the Egyptian Standard, which states that beef burger shouldn't have a moisture content more than 60% (E.S, 1688/2005).

The addition of water and non-meat substances, the amount and kind of processing and cooking, the fat percentage (inverse connection), and other variables can all have an impact on the moisture content (Ali *et al.*, 2020).

5.2. Protein Content

The main element that gives the meat product its structure is protein (Tornberg, 2005). There was a significant difference in the mean protein. For chilled and frozen samples, the mean values of crude protein contents were (15.72 ± 0.66) and (12.96 ± 0.52) , respectively. The mean values of protein percentage of chilled samples were higher than frozen beef burger samples by about 17.56%. These results were lower than those published by Edris *et al.* (2012) (15.22 ± 0.18) and higher than those reported by Ali *et al.* (2020) (11.54) for the frozen beef burger. These findings demonstrated that 19 (63.3%) of the frozen samples and 11 (36.6%) of the chilled samples did not comply with the Egyptian Standards (E.S, 1688/2005), which set a minimum protein concentration of 15%.

5.3. Fat Content

A beef burger is a product that is enjoyed all over the world; they are typically made of 70% to 75% meat and 25% to 30% fat (Moghtadaei *et al.*, 2018). The mean values of ether extract content for chilled and frozen samples were 12.60 ± 1.19 and 10.86 ± 0.86 , respectively. Fat analyses did not show a significant difference ($p > 0.05$) between means and they fulfilled the requirements of the Egyptian Standards (E.S, 1688/2005), which sets a maximum of 20% for lipid content. They also revealed that two (6.6%) of frozen samples and four chilled samples (13.3%) did not meet Egyptian standards. These results were lower than that reported by Ali *et al.* (2020) "17.13" and by Edris *et al.* (2012) " 19.80 ± 0.19 " in the frozen beef burger.

The industry's attempts to save costs and the development of low-fat meat products could have resulted in adulteration, which would have prevented their products from

meeting the required standards (Ali *et al.*, 2020).

5.4. Ash Content

Ash is a representation of all the minerals contained in food, including sodium, phosphorus, and iron, which can come from salt and spice additions as well as meat used as a raw material (Fernández-López *et al.*, 2006). There is no significant difference between the means ($p > 0.05$). It is stated that the mean ash concentrations for chilled samples were (2.85 ± 0.13) and frozen samples were (2.89 ± 0.08). These results were lower than those reported for frozen beef burgers by Ali *et al.* (2020), "4.01," and Edris *et al.* (2012), " 3.36 ± 0.07 ."

5.5. Carbohydrate Content

Mainly, carbohydrates in burgers are from the use of starches as ingredients. Starches, such as maize, tapioca, rice, potato, and wheat, have been used as meat filler and water binder and this result could be due to using of cheap ingredients like rusk, bread crumbs, cereal, and soya protein (Joly and Anderstein, 2009).

A significant increase in carbohydrates in frozen burger samples than in chilled samples. The mean values of total carbohydrate contents were (12.55 ± 0.58) in frozen samples and (7.27 ± 0.66) in chilled samples. These results were higher than that reported by (Ali *et al.*, 2020) of "6.29". The Egyptian Standards (E.S, 1688/2005) for beef burgers stated that carbohydrates should not exceed 10%. This met the requirements of (EOS, 2005) in chilled samples only and showed that 14 of the frozen samples (46%) were not in compliance with (Egyptian standards 1688/2005).

6. Keeping quality characteristics of beef burgers (frozen and chilled).

6.1. pH values

One of the most perishable things among the many foods is meat, which has a moderate pH and a high nutritional and moisture content. Meat spoilage and nutrient breakdown are primarily influenced by microbial growth, lipid oxidation, and enzymatic autolysis. As a result, the meat develops unpleasant flavors and odors, forms slime, and becomes discolored, rendering it unfit for human consumption (Pellissery *et al.*, 2020).

Table 4 shows the keeping quality characteristics of beef burgers (frozen and chilled). Highly significant differences ($p < 0.05$) were obtained in pH values in both frozen and chilled beef burger samples. In frozen samples, burgers registered higher pH values (6.39 ± 0.02 .) than the chilled sample (5.89 ± 0.03). The results reported by Edris *et al.* (2012) of " 5.97 ± 0.02 " were higher than the present study on the frozen beef burger. While results reported by Wesam *et al.* (2022) in refrigerated beef burger samples were " 6.0 ± 0.3 " and were slightly higher than the present study in the chilled beef burgers. All pH values in the chilled burger sample were within the typical value "6" in chilled meat established by Egyptian Standard (ES: 3602 /2013), while 53.3% of the frozen sample weren't in compliance with the acceptance limit of pH values for (5.6-6.2) that established by Egyptian Standards (ES: 1522 -2005) for frozen meat.

6.2. Food Additive (Phosphates):

Food-grade phosphates are one of the food additives that are frequently used in a variety of products. For a variety of technological reasons, phosphorus additions (E338-341, E343, and E450-452) are being used more frequently in processed and fast food, particularly in the meat industry. They improve food

stability, preserve moisture or color, emulsify ingredients, and enhance flavor, in addition to increasing water holding capacity (WHC). Despite the advantages of its technology, it has been estimated that food additives known as "hidden phosphorus" account for 50% of daily phosphorus (P) intake in the Western world (Calvo *et al.*, 2019). Alkaline phosphates are employed in all phosphate blends that are used in meat, and when they are added to somewhat sour meat, the pH of the meat product rises (Long *et al.*, 2011).

Regarding that, the higher pH values found in frozen samples with higher phosphate values (0.373 ± 0.3928) compared to chilled beef burger samples with low phosphate values (0.192 ± 0.2064) showed lower pH values. Lower results were 0.21 ± 0.01 reported by Hassan *et al.* (2018); higher results were 0.399% recorded by EL-Sayed (2006), EL-Zahaby (2013), $0.43 \pm 0.02\%$ by Nayel (2013) and $0.4 \pm 0.019\%$ by Salim and El-Roos (2013) for a frozen beef burger.

The label does not specify the percentage of phosphate that has been analyzed in the samples. (53.3%) from frozen beef burger samples were not accepted according to Egyptian Standards (E.S, 1688/2005). While all chilled samples (100%) fell within the permitted range as indicated by the Egyptian standard specifications that were no more than 0.3%. These variations could be explained by the addition of alkaline phosphates during the production of meat products. This increase in pH will cause electrostatic repulsion between or within the proteins in the meat, leading to a higher WHC (Glorieux *et al.*, 2017). Protein-bound phosphorus found naturally is absorbed more slowly and inefficiently (60%) than phosphorus

found in dietary additives, which is promptly and nearly completely absorbed (Wallace *et al.*, 2021). In patients with chronic renal disease and bone health issues, a link between high serum phosphate levels (hyperphosphatemia) and excessive phosphate intake has long been shown (EFSA FAF Panel, 2019).

6.3. Lipid oxidation of beef burgers (TBARS):

One of the key issues limiting the quality and acceptability of meat and meat products is lipid oxidation. The oxidative rancidity that develops in beef products during storage is measured using the thiobarbituric acid (TBA) value (malonaldehyde/kg) (Abdelhakam *et al.*, 2019). Both the frozen and chilled beef burger samples showed no significant differences ($p > 0.05$). In frozen samples, TBARS' mean values were (0.46 ± 0.07 mg MDA/kg), while chilled samples showed TBARS' mean values (of 0.53 ± 0.08 mg MDA/kg). Nearly similar results obtained by (Hassanien *et al.*, 2018) were "0.44", while lower than those (Malak and Abdelsalam, 2021) " 0.66 ± 0.02 ". On the other hand, our findings were higher than those published by Edris *et al.* (2012) for frozen beef burger samples (" 0.11 ± 0.01 ") and Wesam *et al.* (2022) for refrigerated beef burger samples (" 0.25 ± 0.025 "). According to the Egyptian standards (ES: 3602 /2013) and (ES: 1522 -2005) is not more than 0.9 mg malonaldehyde/kg sample. Four samples (13.3%) of frozen beef burgers and five (16.6%) from chilled samples were recorded above the permissible limit. High levels of bacteria are the cause of meat rotting, while aerobic circumstances result in moisture and protein content, both of these elements can also lead to the oxidation of lipids and proteins, which can jeopardize the safety of food (Tometri *et al.*, 2020).

6.4. Total Volatile Nitrogen (TVN mg/100g)

Being meat a perishable product, it undergoes chemical compositional changes during storage as a result of the activity of endogenous enzymes and microbes. A common biomarker of the breakdown of proteins and amines is total volatile basic nitrogen (TVB-N). TVB-N increases with beef storage and is in line with other biomarkers of decomposition (i.e., a function of duration, temperature, packaging, etc.), however, these increases are not always constant (Bekhit *et al.*, 2021). The mean value of TVN value was 12.16 ± 0.64 mg% for a frozen beef burger and 11.93 ± 1.25 mg% for a chilled beef burger. No Significant difference among means of TVB-N ($p > 0.05$) in frozen and chilled beef burger samples. These findings exceeded those of Edris *et al.* (2012), who reported " 10.15 ± 0.32 mg%" in the frozen beef burger. All frozen samples fell within the permitted range as indicated by the Egyptian standard specifications in 2005 for total volatile nitrogen concentrations, which were not to exceed 20 mg N/100 g. While four samples (13.3%) of chilled samples were recorded above the permissible limit.

7. Microbiological examination:

Due to a rapid decline in quality indices and microbiological development, beef burger patties have a maximum shelf life of 3 days at 4°C (Parafati *et al.*, 2019). While some additives with antioxidant functionality are permissible in fresh minced beef preparations, as mentioned in Regulation EU 601 (2014), no additive with antimicrobial activity is allowed. If the storage temperature and duration are not controlled, pathogenic bacteria can grow and produce poisons in beef burgers, making them potentially deadly products (Saleh *et al.*, 2022). Table 5 shows the results of the microbiological analysis of

frozen and chilled beef burger samples. According to EOS (2005), the analyzed samples were within the parameters that permitted them to be used for sensory analysis.

7.1. Total bacterial count (\log_{10} cfu/g)

The aerobic plate count (APC) or total viable count (TVC) are two of the terms used to describe the standard plate count (SPC), one of the most commonly used tests used to determine the microbiological quality of food (Shaltout *et al.*, 2022).

There was no discernible difference between the total bacterial count (TBC) and mean (\log_{10} cfu/g) in this study in examined chilled and frozen samples ($P > 0.05$). The average values of the chilled and frozen beef burger samples were 4.62 \log_{10} cfu/g and 5.04 \log_{10} cfu/g, respectively. These numbers were therefore deemed to have been met as advised by EOS (2005).

The higher TBC (\log_{10} cfu/g) results (5.49), (5.48 ± 4.81), (5.61 ± 5.45), (5.62 ± 5.11), and (7.65 ± 7.15) were recorded by Ragab *et al.* (2016), Salem *et al.* (2018), Abuelnaga *et al.* (2021), Shaltout *et al.* (2022), and Wesam *et al.* (2022). However, Mousa *et al.* (2014) achieved lower results, reporting that the total aerobic bacterial counts in Egyptian beef burgers were 2.91 \log_{10} cfu/g. From all the examined frozen and chilled samples, seven (23.3%) and four (13.3%) respectively, were deemed to be out of compliance with the Egyptian Standard (E.S) (1688 -2005), which establishes that the aerobic bacterial count shouldn't be more than 10^5 for TBC.

7. 2. Total psychotropic count (\log_{10} cfu/g)

Psychotropic bacteria are the primary cause of meat product spoilage when kept in a refrigerated environment due to their propensity to proliferate at low temperatures. The total amount of psychotropic bacteria can tell you a lot about how well various meat products will keep (Shaltout *et al.*, 2022). No significant difference among means of total psychotropic count (\log_{10} cfu/g) in both types of the examined samples ($P > 0.05$), the mean values for frozen beef burger samples were $(3.58 \pm 3.34 \log_{10}$ cfu/g), whereas the mean values for chilled samples were $(3.82 \pm 3.54 \log_{10}$ cfu/g). Shaltout *et al.* (2022) looked at 25 samples of beef patties that were ready to eat, and the results showed that the range for the total amount of psychotropic count was $> 10^2$ to $> 10^2$.

7.3. Total yeast and mold count (\log_{10} cfu/g)

Fungi can induce three forms of disorders, namely mycosis, mycotoxicosis, and allergies, and are therefore regarded as a major public health risk (Abuzaid *et al.*, 2020).

In terms of total yeast and mold count (\log_{10} cfu/g), there were significant differences between means ($P < 0.05$) of the frozen and chilled examined samples, with mean values of $3.39 \pm 2.75 \log_{10}$ cfu/g and $3.85 \pm 3.05 \log_{10}$ cfu/g in frozen and chilled beef burger samples, respectively. Mousa *et al.* (2014) found similar results, with overall fungal counts of $2.67 \log_{10}$ cfu/g in an Egyptian beef burger. While higher findings were obtained in the frozen burger $(4.21 \pm 3.74 \log_{10}$ cfu/g) by Salem *et al.* (2018), $(3.63 \pm 3.04 \log_{10}$ cfu/g) by Soliman *et al.* (2019), $(3.15 \pm 1.95 \log_{10}$ cfu/g) by Abuelnaga *et al.* (2021), and $(4.59 \pm 4.08 \log_{10}$ cfu/g) by Wesam *et al.* (2022).

CONCLUSION

The current study concluded that the investigated beef burgers had a noticeably different set of quality characteristics. In comparison to the Egyptian standards, the majority of them had higher moisture and carbohydrate levels, and some samples had lower protein content. The content of phosphorus from analyzed frozen beef burger samples (53.3%) was not in the permitted range as indicated by the Egyptian standard specifications (2005), this indicated inadequate quality control and improper manufacturing practice. This finding should be taken with caution, as phosphorus from processed meat products is just one part of the total phosphorus intake from various dietary sources.

RECOMMENDATION

Due to the increased consumption of processed meat, high phosphorus intake from additives should be taken into account as a potential public health concern. Decreased usage of these additives as phosphates in processed meat products by meat industries is recommended and produced in accordance with good manufacturing practices (GMP), especially for those products (beef burgers) that are majorly consumed by child populations. Researchers should conduct periodic evaluations and monitoring on a regular basis for these and other additives produced in the country. Also, to prevent excessive shrinkage during cooking, the amount of added fat in the meat product ingredients should be carefully monitored. These findings suggest that the food industry should move towards using healthier, “greener” technologies for preservation, as this is necessary for the

true change of food systems towards sustainability and nutrition sensitivity.

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دراسة الخصائص الفيزيائية والكيميائية والجودة والتقييم الميكروبيولوجي لبرجر لحم البقر المجمد والمبرد

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تم تصميم هذه الدراسة لمقارنة برجر لحوم البقر المجمدة والمبردة. تم جمع ٦٠ عينة عشوائية من برجر اللحم البقري المجمد والمبرد (٣٠ قطعة لكل منهما) خلال الفترة من مايو إلى أغسطس ٢٠٢٢ من محلات السوبر ماركت المختلفة لـ (برجر اللحم البقري المجمد) وثلاجات أسواق (برجر اللحم البقري المبرد) الواقعة بمدينة أسيوط، مصر. تم فحص العينات لتقييمها الحسي والميكروبيولوجي والفيزيوكيميائي والحفاظ على الجودة. ولتحديد ما إذا كانت النتائج مقبولة، تمت مقارنتها بالمعايير المصرية. أظهرت النتائج أن العينات المجمدة حصلت على درجات منخفضة في التقييمات الحسية ولكنها أعلى في الاختبارات الأخرى من العينات المبردة. فيما يتعلق بالتركيب الكيميائي، لا توجد فروق معنوية بين متوسطات قيم الرطوبة والدهون والرماد لكل من العينات المجمدة والمبردة. هناك زيادة معنوية في متوسط نسبة البروتين في برجر لحوم الأبقار المبردة عن المجمدة، في حين أن نسبة الكربوهيدرات كانت أقل. كانت قيم الأس الهيدروجيني والفوسفات أعلى في عينات البرجر المجمدة (6.39 ± 0.028 و 0.373 ± 39.28) مقارنة بعينات البرجر المبردة (5.89 ± 0.03 و 0.192 ± 20.64). كانت القيم المتوسطة التي تم الحصول عليها لـ TBA (مجم/كجم) و TVBN (مجم/١٠٠ جم) (0.08 ± 0.03 و 0.07 ± 0.46) يمكن أن تشير هذه الدراسة إلى وجود خلل في التصنيع والتخزين في بعض عينات برجر اللحم البقري المبرد والمجمد والتي لا تتمتع بجودة صحية كافية ولا تلبى المتطلبات المصرية، ومن المهم مراعاة المخاطر المحتملة على الصحة العامة المرتبطة بزيادة تناول الفوسفات، وينبغي إجراء رصد وتقييم منتظم من قبل الباحثين لهذه المواد الكيميائية.