Animal Health Research Journal Vol. 9, No. 2, December 2024 pp. 106-119

ISSN: 2356-7767

Trial to obtain high quality chicken burger by adding milk calcium and guar gum

Ghada, A. Abdel Hameed and Walaa, M. Gomaa
Animal Health Research Institute (AHRI), Shebin Elkoom Branch, Agriculture Research Center (ARC)

Research

Corresponding author:
Ghada, A. Abdel Hameed
E. mail: drdodi_201088@yahoo.com

Received in 18/11/2024
Accepted in 23/12/2024

Abstract
Due to the world continuous drive toward modernity and the exponential rise in the consumption of processed foods, natural additives and texturizing agents are in great demand. Thickening agents have gained popularity as a way to alter the overall quality features of food products and improve their rheological and textural qualities. The aim of the study was to evaluate the impact of guar gum and milk calcium on lab-made chicken burgers, with the goal of discovering a natural alternative to phosphate salts. To achieve this, 0.5% milk calcium (MC) and 0.3% guar gum (GG) was added to chicken burger. The samples subjected to chemical analysis (PH- TBA- TVB-N), moisture content, cooking loss and sensory evaluation and the obtained result was cleared that control group spoiled at 6th day but treated samples remained sound till 15th day and there was significance difference ($P<0.05$) between control samples (non-treated) and treated samples, While there was no significance difference ($P>0.05$) between treated samples (0.3% DSP, 0.5% MC and 0.3% GG). So, chicken burger treated with milk calcium (MC) and guar gum (GG) showed properties relatively similar to those of products treated with Di-sodium phosphate (DSP). Therefore, the natural preservatives used in the current study have the ability to substitute synthetic phosphate, in terms of their ability to retain water and subsequently, minimize cooking loss by increasing the pH of the product. But the preference was to GG than MC as the former gives similar action in lower concentration.

Keywords: *Chicken burger; Di-sodium phosphate; Guar gum; Milk calcium*

Introduction

Presently, Egypt has a significant population of customers who consuming chicken and has been sufficient with self-supplies. One of the most common types of animal protein eaten by Egyptians is chicken flesh. The ability to prepare chicken meat into ready-to-eat meals has led to an increase in its popularity **Barbut (2002)**. Furthermore, processed chicken-based products like burgers are sold to restaurants and wholesalers and are also extensively consumed by the public. Additionally, local businesses have expanded to meet the need for these products **Chang *et al.* (2010); Guerrero and Hui (2010)**. Chicken meat and its derivatives are considered to be excellent sources of high-value biological animal protein. Most necessary amino acids needed for growth are present in it and it alsorich in saturated and polyunsaturated fatty acids with minimal cholesterol; it is regarded as a great source of these fats **Mothershaw *et al.* (2009)**. Additionally, chicken flesh is a good supply of minerals like sodium, calcium, iron, phosphorus, sulfur, and iodine needed for growth and maintenance, as well as vitamins like B12, niacin, riboflavin, thiamine, and ascorbic acid **FAO/WHO (2014)**.

As customers awareness of the health and safety implications of the food industry grows, researchers and producers are working to ensure that their products are of high-quality and safety. Food products should not only fulfill consumers nutritional needs but also their sensory needs. As a result of pushing toward modernization and the exponential growth of processed food consumption worldwide, the need for natural additives has increased. New technologies and various natural additives have also been used to solve food processing risks and issues. Due to consumer demand for natural foods, chemical additives used in food processing are becoming less common. Thickening agents are being used in food products more and more frequently to improve their quality attributes and change their rheological and textural features **Ulu (2006); Kilincceker *et al.* (2009) and Tahmouzi *et al*. (2023).**

Clean labeling is a food business movement that has gained popularity recently, despite not being specifically defined by regulatory organizations. The term "clean label" refers to the elimination of "artificial" or "synthetic" additives considered hazardous to human health in processed products, as well as the use of ingredients derived from natural sources and information that is simple to be recognized by customers. Therefore, it is assumed that "clean label" meat products will only have ingredients that are natural and not contain any artificial flavors, colors, or chemicals that increase the consumer trust and satisfaction. Responding to the demands associated with the "clean label" food business trend, the meat industry has researched the application of raw materials of natural origin for use as alternatives to inorganic phosphates **Daniele *et al.* (2017) and Tolba *et al*. (2024).**

Phosphate has numerous uses in the preparation of meat, such as enhancing textural and sensory qualities, preventing lipid oxidation, raising water-holding capacity, and acting as an antibacterial agent **Barbut and Mittal (1991); Long *et al*. (2011) and Thangavelu *et al*. (2019).** Phosphates are essential for human health as they are required for growth, maintenance and repair of cells and tissues, signalling, energy transfer and other important functions. They are involved in many metabolic pathways and are naturally found in the form of organic esters in foods like egg, meat, potatoes and cereals. In general, the acceptable daily intake (ADI) of phosphorus (P) for a healthy adult is 40 mg/kg body weight per day **Younes *et al.* (2019)**. inorganic phosphates are generally regarded as safe (GRAS) by the United States Food and Drug Administration (FDA) and are used as an effective food additive in many processed food products such as meat, ham, sausages, cheese, canned fish, beverages and baked products. Phosphate addition in US is regulated by FDA regulation that controls the maximum usage levels in food products **Dykes *et al.* (2019).** Phosphate is allowed to be added to meat products at a concentration of no more than 0.5% since it is a material that FDA (Food and Drug Administration) has classified as GRAS, or generally recognized as safe **USDA-FSIS (2015).**

Phosphates are chemical synthetic analogues. Studies reveal that a high dietary phosphate intake raises the risk of renal and bone illnesses, as well as expose people at risk for pulmonary and cardiovascular diseases. Phosphate salts have been linked to a number of health hazards, according to recent studies. Due to increased consumption of processed foods, The Safety of phosphate additive consumption was recently reevaluated **Bae *et al.* (2017).** As a result, there has been a push to reduce or replace the amount of phosphates in product formulations with natural ingredients that have comparable technological benefits. Several researches have tried to enhance the functions of meat products by using different functional components, like carrageenan, guar gum, chitosan, and alginic acid, which are examples of functional carbohydrates **Park *et al.* (2008),** 0.2% oyster shell calcium powder, 0.3% egg shell calcium powder and 0.25% whey protein concentrate **Jeong (2018).** Calcium is one of the most important minerals in the human meal, it is necessary for both the structure and function of the body. It is essential for the growth and maintenance of the skeleton and teeth, where it ensures the structural integrity of mineralized tissue. As well as plays a diversity of other roles in the maintenance of cellular and secretory functions, contraction of skeletal muscle, fat mobilization and blood coagulation also it acts as co-factor in a number of enzymatic reactions **Cashman (2002) and Dendougi & Schwedt (2004)**. While milk and milk products remain the best sources of calcium, Researches and the food industry have focused on increasing intake of this mineral by designing an extensive range of calcium- enriched products, ranging from milk products to beverages and even ceraels **Selgos and Garcia (2008)**. Natural calcium powders, which are widely used in meat industry, include egg shell calcium (ESC), oyster shell calcium (OSC), marine algae calcium and whey calcium (milk calcium, MC). Due to differences in their primary sources of raw materials and manufacturing techniques, each of these natural calcium powders has distinct physico-chemical qualities as well as sensory attributes. Consequently, when added to meat products, they offer distinct processing qualities. They successfully take the place of artificially manufactured chemical preservatives **Bae *et al.* (2017**).

Guar gum is water soluble nonionic poly saccharide from the ground endosperm of guar (Cyamopsis tetragonoloba) seeds, which has a main chain of (1-4) linked b-D-mannopyranosl units, bearing single a -D - galactopyranosyl units attached to O-6 of the main - chain units **Whistler and Be Miller (1997)**. Guar gum's capacity to create hydrogen bonds with water molecules makes it useful for a wide range of industrial applications **Tood *et al.* (1990)**. Additionally, just a small amount is required to generate enough viscosity due to its great water -thickening ability **Yousif *et al.* (2017)**. As a result, fewer requirements reduce costs, which is economical **Gupta & Variyar (2018)**. It is used as a binder and fat replacement in the case of meat and its products **Ulu (2006)**. Guar gum stops syneresis in meat and forms a gel that enhances texture and stickiness. By dissolving the gum's solubility in cold water and then adding the swollen material to the meat, sensory qualities are preserved and microbiological contamination is avoided **Tahmouzi *et al.* (2023)**. Additionally, it helps to control several health issues, such as diabetes. Although guar gum may not include all the nutrients that are necessary, its high fiber and low calorie contents contribute to a feeling of fullness **Srinivasan (2020)**. Guar gum is safe to use at a daily dosage of 20 g and is a soluble-fiber source in food products as well as a source of dietary fiber **Grabitske & Slavin (2009)**.

The goal of this study was to increase the meat products' ability to bind and hold water by replacing synthetic phosphate with a variety of natural ingredients, such as guar gum and milk calcium, as well as assessing the product cooking loss. Therefore, the aim of the research was to study the effect of milk calcium (0.5%MC) and guar gum (0.3%GG) on laboratory-prepared chicken burger as a natural preservative to be a safe alternative to phosphate salts (0.3% Di-sodium phosphate) and to determine which one have the better effect.

Materials and Methods

The preservatives used in the experiment.

Milk Calcium (MC) AR, AVI-CHEM LAB., India, CAS: 7440-70-2FW: 40.08, Min. Assay (99.5%).

Guar gum (GG) AR., AVI CHEM. LAB., India, CAS: 9000-30-0.

Dibasic Anhydrous Purified Sodium Phosphate (Na_2HPO_4), India. www. Labachemia. com

All preservatives used in this study were of analytical grade and the doses of the preservatives used in the present study (GG 0.3% and MC 0.5%) which recommended through several investigations have used the same concentrations or through international references that have approved the use of such concentrations **SCF (2001) & (2003), Yoko (2008) and US-FDA (2019).**

Preparation a solution of preservatives according to Srichamroen (2007)

Aqueous solutions [Di-sodium phosphate (DSP) 0.3%], GG (0.3%) and MC (0.5%) were prepared on a weight-to-volume (w/v) basis using clean distilled water in a boiling water bath for 30 min, with gentle stirring to ensure homogeneity, The solutions were cooled and held at 4°C for 2 h, with gentle stirring to ensure homogeneity.

Chicken meat:
One sample weighted six kg of fresh chicken fillet was purchased from slaughtering shop in menofia, transferred under strict hygienic measures to the laboratory as soon as possible.
Chicken burger manufacture:
Fresh chicken burgers were prepared as described by **Mikkelson (1993)** and **Abd EL-Qader (2004).** The control chicken burger consisted of 71.50% minced chicken meat (included fat), 12.0% rehydrated texturized soy, 6.30% fresh eggs, 7.0% fresh onion, 1.50% salt and 1.70% spices.
Texturized soy:
Texturized soy was obtained from the Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. It was rehydrated by water at a ratio of 1:2 (w/v) and minced twice through 3 mm plate.
Spices mixture
The spices were purchased from the local market in Menofia, Egypt. The spices (60.0% fennel, 27.0% coriander, 3.0% Chinese cubeb, 3.0% white pepper, 3.0% clove, 2.0 % laurel leaf powder and 2.0 % cardamom.) were mixed together then ground to pass through a 60 mesh sieve and kept in a tight jar.
The chicken fillet was minced by using meat mincer. The aforementioned ingredients were added and mixed by using a laboratory blender (Hobart Kneading machine, Italy) together. After blending, the chicken mixture was shaped manually using a patty maker (stainless steel model "Form") to obtain round discs of 10 cm diameter and 0.50 cm thickness. . After the formulation of chicken burgers, the samples were divided into four groups (200 g for each) and treated as follows:
The 1st group considered control without any treatment.
The 2nd group treated with addition of 0.3% Na_2HPO_4.
The 3rd group treated with 0.5% MC.
The 4th group treated with 0.3% of GG.
The samples were packaged in the foam plates, wrapped with polyethylene film and put in the refrigerator at 4°C, then analyzed every three days till the marks of the visual deterioration process become clear in each group, where the experiment was performed in triplicate.

Quality indicators analytical procedures
PH value: -
Ten grams of chicken burger were homogenized and mixed thoroughly with 100 mL of distilled water for measuring of pH using a digital pH meter (Suntex TS-1, Taiwan) equipped with a probe-type combined electrode (In gold) through direct immersion of electrode into the mixture at room temperature according to the method recommended by **AOAC (2002).**
Thiobarbituric acid – Reactive substances (TBARS) measurement:
The TBARS of the chicken burger was determined according to the method described by **Egyptian Organization for Standardisation "EOS" 63/9 (2006).** The TBA values were expressed as mg malonaldehyde/ kg of sample.
Total volatile basic nitrogen (TVBN):
The TVBN of the chicken burger was determined by the method described by **Egyptian Organization for Standardisation "EOS" 63/10 (2006).**
Moisture content: -
Moisture contents of raw minced meat samples were determined using hot air oven method at 105±2 C^O according to **AOAC (2002).**
Determination of cooking loss according to (Bae *et al.*, 2017)
Weight of each sample prior to cooking and then again after cooking and cooling to calculate the cooking loss according to as the following calculation:

$$\text{Cooking loss (\%)} = \frac{\text{Weight before cooking} - \text{Weight after cooking}}{\text{Weight before cooking}} \times 100$$

Sensory evaluation:
The chicken burgers were grilled on a hot plate with little sunflower oil at 110oC for 4 minutes and left to cool at room temperature for 15 min. Sensory properties of cooked chicken burgers were carried out according to **Mansour and Khalil (1999)** by ten-trained panelists.
Randomly coded samples were served to panelists individually. Five sensory attributes were evaluated (taste, odor, color, texture, and overall acceptability) using ten points hedonic scale for each trait where 9-10 = like extremely, 7-8 = like very much, 6 = like moderately, 5 = neither like nor dislike, 4 = dislike moderately, 3 = dislike very much and 1-2 = dislike extremely.

Statistical analysis:
The data obtained were analyzed by one-way analysis of variance (ANOVA), using the Statistical Package of Social Science (SPSS). The values obtained were then expressed as mean ± standard deviation (SD), with $p < 0.05$ being therefore considered as statistically significant. Duncan's multiple range tests was applied for the comparison of means and for the determination of the significant difference cause.

Results

Table (1). Effect of different preservatives on the physico-chemical properties of laboratory manufactured chicken burger

Treatment	Storage days					
	Zero day	3	6	9	12	15
	pH					
Control	5.68±0.01	6.11±0.02A	6.83±0.02A	S	S	S
Na2HPO4 (0.3%)	5.81±0.01	5.97±0.04aB	6.06±0.05aB	6.14±0.03	6.48±0.03	6.65±0.03
MC 0.5%	5.70±0.02	5.94±0.04aBC	5.99±0.02aBC	6.09±0.02	6.46±0.04	6.61±0.04
GG 0.3%	5.70±0.01	5.91±0.05aBC	5.98±0.04aBC	6.01±0.03	6.35±0.03	6.60±0.06
	TBARS (mg MDA/kg)					
Control	0.18±0.012	0.41±0.015A	0.72±0.050A	S	S	S
Na2HPO4 (0.3%)	0.16±0.012	0.34±0.015aB	0.41±0.015aB	0.53±0.05	0.84±0.07	0.95±0.12
MC 0.5%	0.17±0.012	0.36±0.018aBC	0.42±0.012aBC	0.58±0.07	0.85±0.07	1.06±0.10
GG 0.3%	0.16±0.003	0.35±0.012aBC	0.41±0.015aBC	0.53±0.06	0.85±0.09	0.98±0.07
	TVB-N (mg/ 100 gm)					
Control	4.20±0.40	5.55±0.20A	15.88±1.23A	S	S	S
Na2HPO4 (0.3%)	3.97±0.12	4.39±0.12aB	5.65±0.12aB	7.71±0.40	13.31±0.40	18.68±1.24
MC 0.5%	4.15±0.12	4.57±0.17aBC	5.66±0.22aBC	8.41±0.40	14.24±0.61	19.61±0.81
GG 0.3%	4.01±0.12	4.53±0.2aBC	5.65±0.20aBC	8.18±0.62	13.78±0.84	19.15±1.23
	Moisture content					
Control	67.68±1.15	66.45±0.59A	65.82±0.33A	S	S	S
Na2HPO4 (0.3%)	68.15±0.53	68.11±0.61aB	67.85±0.63aB	67.58±0.64	67.43±1.08	67.41±0.44
MC 0.5%	68.13±1.17	68.01±0.64aBC	67.37±0.33aBC	67.32±0.83	67.28±1.38	67.23±0.58
GG 0.3%	68.22±1.08	68.14±0.66ABC	67.98±0.34aBC	67.68±1.12	67.64±1.21	67.60±0.64

There is a significant difference between means have the same capital and small letter in the same column (P< 0.05).
S= Spoiled

Table (2). Effect of different preservatives on cooking loss of laboratory manufactured chicken burger

Treatment	Storage days					
	Zero day	3	6	9	12	15
Control	33.55±1.0	34.60±1.82A	34.93±0.18A	S	S	S
Na2HPO4 (0.3%)	32.02±0.46	32.17±0.17aB	33.20±0.30aB	33.33±0.33	33.40±0.30	33.43±0.54
MC 0.5%	32.05±1.15	32.22±1.20aBC	32.26±0.50aBC	32.43±0.59	32.49±0.58	33.53±0.35
GG 0.3%	32.07±0.98	32.27±0.55aBC	32.30±0.46aBC	32.50±0.46	33.52±0.45	33.60±0.36

There is a significant difference between means have the same capital and small letter in the same column (P< 0.05).
S= Spoiled

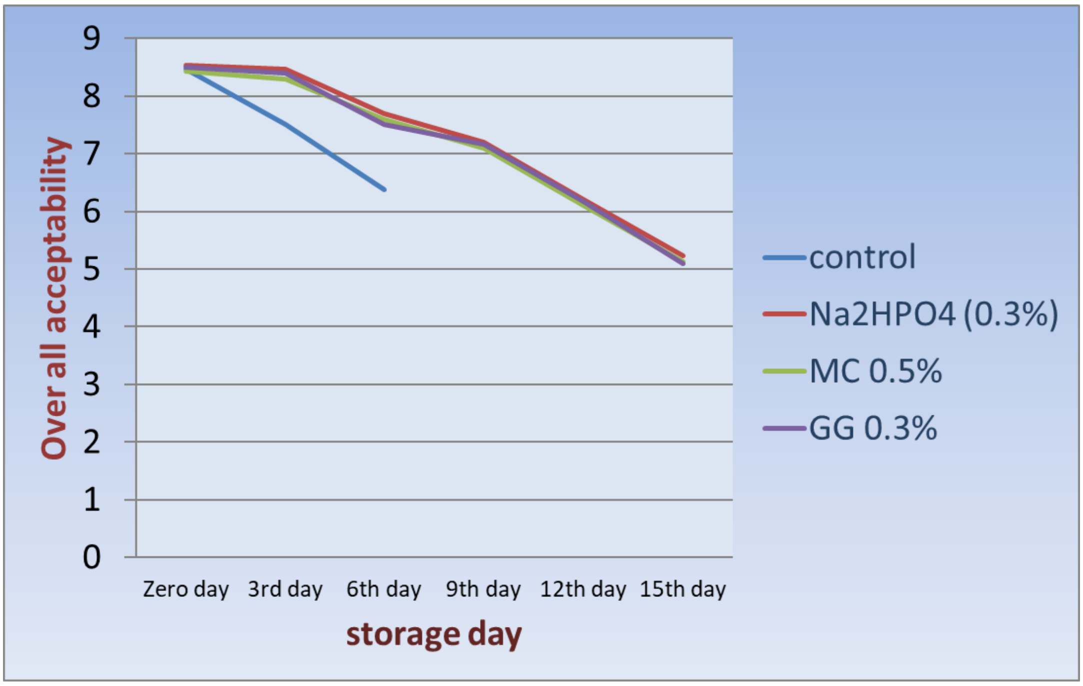

Figure (1). Effect of different preservatives on sensory attributes of lab manufactured chicken burger

Table (3). Effect of different preservatives on the sensory attributes of laboratory manufactured chicken burger

Treatment	Storage days					
	Zero day	3	6	9	12	15
	Taste					
Control	8.4±0.1	7.3±0.3A	6.3±0.1 A	S	S	S
Na2HPO4 (0.3%)	8.55±0.3	8.6±0.4aB	7.8±0.3aB	7.4±0.23	6.2±0.33	5.5±0.01
MC 0.5%	8.4±0.1	8.4±0.3aBC	7.6±0.4aBC	7.1±0.42	6.3±0.16	5.3±0.16
GG 0.3%	8.5±0.3	8.3±0.4aBC	7.7±0.3aBC	7.2±0.33	6.3±0.15	5.4±0.19
	Odor					
Control	8.4±0.1	7.5±0.5A	6.1±0.1A	S	S	S
Na2HPO4 (0.3%)	8.5±0.1	8.2±0.3aB	7.8 ±0.3aB	7.2±0.2	6.1±0.1	5.3±0.1
MC 0.5%	8.2±0.1	8.1±0.1aBC	7.6±0.2 aBC	6.9±0.3	5.9±0.2	5.1±0.1
GG 0.3%	8.6±0.2	8.3±0.3aBC	7.4±0.1aBC	7.0±0.3	6.1±0.1	5.2±0.2
	Color					
Control	8.8±0.4	7.8±0.3A	6.2±0.1A	S	S	S
Na2HPO4 (0.3%)	8.7±0.2	8.7±0.2 aB	7.8±0.3aB	7.3±0.1	6.2±0.2	5.4±0.1
MC 0.5%	8.7±0.1	8.6±0.1aBC	7.7±0.2aBC	7.1±0.3	6.1±0.2	5.3±0.2
GG 0.3%	8.7±0.2	8.6±0.2aBC	7.6±0.2aBC	7.2±0.2	6.2±0.1	5.3±0.1
	Texture					
Control	8.20±0.2	7.17±0.1A	6.23±0.1A	S	S	S
Na2HPO4 (0.3%)	8.40±0.1	8.20±0.1aB	7.86±0.2aB	7.33±0.2	6.33±0.2	5.17±0.1
MC 0.5%	8.37±0.1	8.27±0.1aBC	7.77±0.2aBC	7.20±0.2	6.17±0.1	5.00±0.1
GG 0.3%	8.43±0.3	8.33±0.3aBC	7.90±0.3aBC	7.27±0.1	6.27±0.1	5.23±0.1
	Overall acceptability					
Control	8.47±0.3	7.50±0.3A	6.37±0.2A	S	S	S
Na2HPO4 (0.3%)	8.53±0.1	8.47±0.3aB	7.70±0.4aB	7.20±0.1	6.20±0.2	5.23±0.1
MC 0.5%	8.43±0.3	8.30±0.1aBC	7.60±0.2aBC	7.10±0.3	6.10±0.2	5.13±0.1
GG 0.3%	8.50±0.3	8.40±0.2aBC	7.50±0.3aBC	7.17±0.2	6.17±0.1	5.10±0.1

There is a significant difference between means have the same capital and small letter in the same column ($P < 0.05$).
S= Spoiled

Discussion

Natural alternatives to chemical synthetic materials are becoming more and more popular as a result of consumers' growing interest in processed foods with less artificial ingredients. Meat manufacturers are looking for new and improved substitutes for phosphates, which are chemically synthesized additives used in meat products. Synthetic phosphate replacers have been found their way to meat processors and researchers since the natural material has a good challenge to preserve the natural useful qualities as well as remaining reasonably priced for the finished product **Jeong (2016); Sindelar (2015).**

Milk calcium (MC) and guar gum (GG) are effective as a natural preservative replacer for synthetic phosphate in meat products. Additionally, it can maintain the product's quality by maintaining a high moisture content, which lowers cooking loss, enhances product palatability and protects the consumer's health from the harmful effects of chemical or artificial preservatives **El-Shinawy and Abdelmonem (2020) and Tolba *et al.* (2024).**

Elevating the pH and ionic strength of meat mixtures allows for better water retention due to the alkaline nature of phosphate employed as a preservative in meat products **Sebranek (2009) and Choi *et al.* (2014).** Because various alternatives have varying capacities to store water and so raise the product's water holding capacity, which in turn improves the product yield, pH plays a significant role in determining which one to use as a synthetic phosphate substitute in meat products. USDA-FSIS (2015) found that the maximum acceptable level of phosphates in meat and poultry products was 0.5%, while it is used by 0.3-0.4% in meat product industry **Sebranek (2009).**

The obtained data in Table (1) concerning that mean±SD of pH values of control and treated samples during storage at 4^{o}C showed significance difference ($P<0.05$) between control samples (non-treated) and all groups of treated samples. While, there were no significance differences ($P>0.05$) between treated samples with (0.3%) of DSP, 0.5% milk MC and 0.3% GG. It was clear that, 0.3% DSP, MC 0.5% and GG 0.3% groups had higher pH (5.81±0.01, 5.70±0.02 and 5.70±0.01) respectively, than control group (5.68±0.01) in zero day of storage. Control group spoiled at 6th day but treated samples remained till 15th day. At 15th day of preservation pH in 0.3% DSP, MC 0.5% and GG 0.3% samples was 6.65, 6.61 and 6.60, respectively.

PH gradually increases in all groups during storage. An increase in pH values over the period of storage may be caused by the degradation of proteins and the production of protein metabolites, particularly amines **Reddy *et al.* (2013).**

The breakdown of proteins by natural enzymes and meat spoilage microorganisms may be the primary cause of the increase in ammonia, amines, and other basic chemicals **Jimenez *et al.* (1997), Ding *et al.* (2020), Assanti *et al.* (2021)**.

These results agreed with that obtained by **Yoon *et al.* (2023) and El-Shinawy & Abdelmonem (2020)** who stated that mean±SD of pH values showed significance difference ($P<0.05$) between 0.5% GG and each of control samples and 0.3% MC while, no significance differences ($P>0.05$) of recorded pH between all other treatments (0.3% Di-sodium phosphate, 0.3% GG, 0.5% MC). The same results agreed with that of **Tolba *et al.* (2024)** except presence of significance difference ($P<0.05$) between control and Na_2PHO_4 (0.3%), while absence of such difference between control and 0.3% MC.

Also the results agreed with **Jeong (2016)** who reported that there was no significance difference ($P>0.05$) between pH of control samples treated and samples treated with MC. Furthermore, results in the current study agreed with **Bae (2017)** who reported that since calcium powder reduced cooking loss by raising the product's pH, it was a good option to replace phosphate in formulations.

The neutral composition of guar gum makes it stable over a broad pH range. At a pH of >10 and less than 4, the lowest water absorption happens, whereas the highest occurs in the 8–9 range. According to **Maier *et al.* (1993),** guar's glycosidic structures are destroyed and its viscosity rapidly drops at pH <3. Study findings indicate that the viscosity rate is lowest at pH 3.5 and maximum in GG at pH 6 and 9 **Zhang *et al.* (2005).**

Meat deterioration can be attributed primarily to lipid oxidation. A common indicator of lipid oxidation in meat products during storage is the TBA test, which measures the concentration of malondialdehyde (MDA), the main secondary by-product of lipid oxidation. The evaluation of TBA mean values of control and treated samples during storage at 4^oC are shown in table (1). The highest incremental rate was recorded in the untreated (control) samples, mean ± SD of TBA values showed significance difference (P<0.05) between control samples (non-treated) and treated samples. While, there was no significance differences (P>0.05) between treated samples (0.3%) DSP, MC (0.5%) and GG (0.3%). as TBA values decrease in the treated samples compared with control samples from 0.18, 0.41 and 0.72 in control group to 0.16, 0.34 and 0.41 in sample treated with DSP 0.3%, while it recorded 0.17, 0.36 and 0.42 in samples treated with MC (0.5%) as well as 0.16, 0.35 and 0.41 in samples treated with GG (0.3%) at 0, 3^{rd}, 6^{th} days, respectively. TBA values at 15^{th} day were 0.95, 1.06 and 0.98 in DSP 0.3%, MC 0.5% and GG 0.3%, respectively.

The progressive pattern observed in TBA values across all preserved samples as the chilling storage period increased could potentially be attributed to meat lipid auto-oxidation, bacterial, or oxidative rancidity. TBA value is frequently utilized as a lipid oxidation measure in commercial beef products **Raharjo and Sofos (1993)** and the rancid flavor is initially detected in meat products between TBA values of 0.5 and 2.0 **Abdulla *et al.* (2013)**. Furthermore, because chicken cuts have a high level of unsaturated fatty acids, that makes them more susceptible to rancidity, the rancid flavor can spread quickly when stored in a refrigerator or freezer **Edris *et al.* (2012)**.

A good antioxidant is GG. Because hydrocolloids are hydrophilic, they have a restricted ability to resist moisture, prevent the flow of carbon dioxide and oxygen, and protect lipids from oxidation **Liberty *et al.* (2019); Porta *et al.* (2012).**

The MDA values in chicken burgers were maintained in all treatments and throughout storage at low levels, with a higher value of 0.98 mg MDA/kg. This value is substantially lower than the reported perception threshold of 2 mg/kg for oxidized odors **Byun *et al.* (2003)**. The very low MDA values recorded can be justified by the very low fat content of chicken breast meat used in the study.

Additionally, the elimination of phosphate did not significantly (p>0.05) alter the TBARS levels of ground pork products treated with oyster shell calcium **Yoon *et al.* (2023)**. **Lee *et al.* (2011)** reported that oyster shell calcium had similar efficacy in inhibiting lipid oxidation as sodium tripolyphosphate in emulsion-type sausages.

Total volatile basic nitrogen, (TVB-N) is linked to the activity of amino acid decarboxylase microorganisms during storage and may be utilized as a quality indicator for fish and meat products **Jitoe *et al.* (1992)**. One key indicator of meat freshness is the TVB-N level **Wang *et al.* (2022)**.

Changes in TVB-N values in the chicken burger samples during storage at 4^oC for ١٥ days of are summarized in Table (1). When evaluating the degree of beef deterioration during the storage period, the TVB-N value tended to gradually increase. The TVN measurements increased at varying rates for each of the chicken burger samples during the 4ºC storage period. This could be explained by the way that microbial strains and proteolytic enzymes break down proteins **Yassin - Nessrien (2003)**. **(ES, 2910 - 2005)** stated that 20 mg TVB-N/ 100 gm raw meat samples indicates the spoilage of meat. The TVB-N values of chicken burger samples showed significant differences between the control and treated samples (P<0.05) but there was no significance differences (P>0.05) between samples treated with MC 0.5%, GG 0.3% and DSP 0.3%.

The control sample had higher TVB-N values than samples treated with DSP 0.3%, MC 0.5% and GG 0.3%. TVB-N values decrease from 4.2, 5.55 and 15.88 at zero, 3rd day and 6th day respectively, in control sample while it recorded 3.97, 4.39 and 5.65 in disodium phosphate 0.3% treated group and 4.15, 4.57 and 5.66 in MC 0.5% treated group and to 4.01, 4.53 and 5.65 in GG 0.3 % treated group. Where, TVB-N values at 15^{th} day recorded 18.68, 19.61 and 19.15 for DSP 0.3%, MC 0.5% and GG 0.3%, respectively.

The bacterial breakdown that occurs during the preservation of chicken burgers may be the cause of increase TVBN readings. TBA and PV readings may have increased during the storage period as a result of ongoing lipid oxidation and the resulting generation of oxidative byproducts **Osheba and Abd El-Bar (2007).**

Phosphates serve a variety of functions in meat products, including water-binding, emulsification, color stability, oxidation inhibition, buffering, antibacterial activity, and protein dispersion. However, their main uses are in emulsifying and stabilizing meat products, which have a significant impact on their ability to hold water **Long *et al.* (2011).**

The moisture content of chicken burger was considered as indicator of the water holding capacity, and the results are shown in table (1). Indicated that control samples (67.68%), and treated samples with Disodium phosphate (68.15%), MC (68.13%) and GG (68.22%) had nearly the same moisture contents (p>0.05), control sample had significance differences (P<0.05) with samples treated by MC 0.5%, GG 0.3% and disodium phosphate 0.3% but there were no significance differences (P>0.05) between treated disodium phosphate 0.3% samples, MC 0.5% and GG 0.3% samples.

The moisture content of the chicken burger treated with Disodium phosphate, MC and GG was showed a gradual decrease in mean values to reach 67.41%, 67.28% and 67.60 % respectively, in day 15 of refrigerated storage.

Thus, the addition of guar gum to chicken burger had almost similar or better effects on water retention than the addition of synthetic phosphate.

The results obtained in the present research are consistent with **Bae *et al.* (2017)** who reported that samples treated with MC had the lowest moisture content (66.17%) compared to other treated samples (P < 0.05) and then had a moisture retention power of water lower than that of inorganic phosphate.

El-Shinawy and Abdelmonem (2020) found that the samples treated with GG (0.5%) had a significantly high value (P<0.05) of moisture content (64.09±0.05), which is considered an indicator of the water holding capacity also compared to GG 0. 3% (63.50 ± 0.05), while the highest moisture content was recorded in the samples treated with Na2Hpo4 (64.32 ± 0.07), while there was no significant difference (P > 0.05). 05) in the moisture content between the samples treated with both of MC 0.3% and 0.5% as they recorded almost the same moisture content (63.44±0.30 and 63.5%) . 55±0.04), respectively.

Variation in the moisture content of meat products may be due to the type and amount of preservatives used, as well as the type of meat products **Cofrades *et al.* (2008); Lee *et al.* (2011) and Casco *et al.* (2013).**

Due to absence of phosphates, the pH of the meat product decreased and approached the isoelectric pH of the myofibrillar proteins. This led to a reduction in their net charge and the repulsion between the proteins, causing a negative impact on the binding of water and fat **Offer and Trinick (1983).** In this respect, GG is inexpensive and widely used due to its unique properties that make it an essential component of food applications, including reduced evaporation rate, modification of rheological properties, improved freezing rate and improve the formation of ice crystals **VonBorries-Medrano *et al.* (2016).**

In this respect, **Demirci *et al.* (2014)** concluded that the moisture content increased in cooked meatballs formulated with GG. This is because GG forms a strong template that prevents the migration of water from cooked or fried foods into the surrounding environment. These results are consistent with those of the present study. Sensory features and chemical properties are improved with GG in the formulation of chicken nuggets **Yadav *et al.* (2013).**

As shown in table (2), cooking loss of chicken burger samples showed no significant differences between the control sample and the treated samples (P>0.05) at zero, 3 days of storage but there are significance differences (P<0.05) between control sample and that treated with MC 0.5%, GG 0.3% and disodium phosphate 0.3% at 6 day.

Cooking loss is an indicator of value meat nutrition related to levels of meat juice represented by the amount of water bound in and between muscle fibers. Meat juice is a determinant component of meat tenderness **Soeparno (2009)**.

Meat with a low cooking loss value of less than 35% is considered to have good quality because there is less chance of the meat's nutrients being released while cooking **Yanti *et al.* (2008).**

The current study's results were also in line with those of **El-Shinawy & Abdelmonem (2020),** who reported that non significance difference ($P>0.05$) between mean pH value (6.25±0.10) of 0.3% Na2HPO4 and 0.5% Guar gum(6.35±0.05). In turn, less cooking loss was recorded in both treatments (70g / 28%) as it considered the least value recorded among the preservatives used in this study, followed by 0.5% MC (6.20±0.05) and 28.4% cooking loss, then 0.3% of both MC and GG were recorded (6.10±0.01and 6.14±0.03) and cooking loss was 28.8% for both, with absence of significance difference ($P>0.05$). While, all preservatives were recorded significance difference ($P<0.05$) as compared with control samples.

Lee *et al.* (2011) used oyster shell calcium and whey protein (milk calcium) on emulsion-type meat products, demonstrating that the addition of 0.3% oyster shell calcium could significantly improve the cooking loss, compared to products without phosphate

It has been demonstrated that beef rolls with GG, algin/calcium and salt/phosphate structure have better water-holding capacities **Shand *et al.* (1993).** Moreover, hydrocolloid gums (GG) hold onto water to form a gel network that gradually increases their juiciness **(Gupta & Variyar (2018).** It was investigated whether GG and carrageenan could replace phosphate in processing pork sausages. In addition to increasing water-holding capacity, the hydrocolloid compounds also reduced cooking loss. Furthermore, phosphate-free sausages were stable for extended periods **Park *et al.* (2008).**

As shown in table (3) & Fig. (1), the scores of preservatives impacts on taste, odor, color, and texture (10 points, for each) of chicken burger samples which concluded by the mean values of overall acceptability (10points) on sensory acceptability provided by control samples and treated samples (DSP 0.3%, MC 0.5% and GG 0.3%) at different refrigerated storage time. There is a significant difference ($p<0.05$) between control and treated samples at the 3rd and 6th day of storage.

There are no significant differences ($P>0.05$) between samples treated with DSP 0.3%, MC 0.5% and samples treated with GG 0.3%.Thus, the addition of MC and GG to chicken burger had nearly similar effects on overall acceptability as the addition of synthetic phosphate.

So, Natural preservatives enhanced the sensory attributes of chicken burger to be accepted till the 15th day of storage in contrast to that of control group that rejected on the 6th day of storage based on sensory evaluation

Gum inhibits syneresis and gel formation which enhances texture and stickiness of meat. Dissolving the gum in water resulted in swelling of content which when added to meat; it maintains the sensory properties and prevents microbial contamination **Tahmouzi *et al.* (2023).**

Guar gum has a slight laxative effect by absorbing water in the stomach **Feiner (2006).** Guar gum has the ability to be soluble in both hot and cold water, which facilitates simple absorption. As a thickening agent in processed meat products, it primarily aid syneresis of products ingredients, prevents fat migration during storage, and regulates viscosity and rheology **Mudgil *et al.* (2014)**. This agrochemical substance strongly forms hydrogen bonds in water, making it a useful thickener and stabilizer. It is important to keep in mind that guar gum aqueous solutions are very viscous. This is why it has a wide variety of applications in a wide range of industries like food. Besides, the fact that its popularity has also been attributed to its low cost. Additionally, it is used in food products in the form of dietary fiber as a supplement. Therefore, the rising demand for gluten-free and plant-based food products has created new opportunities for GG in the food industry. Guar gum is a gluten-free and vegan substitute for other thickening agents, which makes it a great option for health-conscious consumers. It also lowers cholesterol levels in the body and controls diabetes in humans, which lowers the risk of heart disease. Guar gum is a prebiotic fiber that helps the growth of good gut bacteria, which in turn improves gut health.The use of GG in functional food products such as probiotic yogurts, energy bars, and dietary supplements which expected to increase in the future. This will create new opportunities for GG in the food industry, especially in the health and wellness segment. Therefore, the development of sustainable sourcing practices and the use of alternative thickeners can help ensure the availability and affordability of GG in the food industry **Tahmouzi *et al*. (2023)**.

Conclusion

From the previous data, Chicken burger treated with MC and GG showed properties relatively similar to those of products treated with Disodium phosphate. Therefore, it could be concluded that the natural preservatives used in the current study has the ability to be substitutes for synthetic phosphate, in terms of their safety and quality characters including their ability to retain water and subsequently, minimize cooking loss by increasing the pH of the product. But the preference was to GG as it gives similar action in lower concentration and it is characterized by many other features as this compound strongly forms hydrogen bonds in water, making it a useful thickener and stabilizer. It is important to keep in mind that GG aqueous solutions are very viscous. This is why it has a wide variety of applications in a wide range of industries like food. In addition to being inexpensive, it is added as dietary fiber to food items. Guar gum lowers blood cholesterol and controls diabetes in humans, which lowers the risk of heart disease. It is a great option for health-conscious customers since it is a gluten-free and vegan substitute for conventional thickening agents.

References

Abd El-Qader, F.M. (2004). Quality improvement of chicken frozen burger formulated with some spices or their volatile oils. M.Sc. Thesis, Food Science and Technology Dept., Faculty of Agriculture, Cairo Univ.

Abdulla, G.; El-Araby, M.G. and Toliba A.O. (2013). Egyptian leek extract as a natural antioxidant: application on beef burger. Alex. J. Fd. Sci. and Technol., 10 (1): 1-10.

AOAC (2002). Official methods of analysis (17th ed.). Association of Official Analytical Chemists, Washington.

Assantiو E.; Karabagias, V.K.; Karabagias, I.K.; Badeka, A. and Kontominas, M.G. (2021). Shelf life evaluation of fresh chicken burgers based on the combination of chitosan dip and vacuum packaging under refrigerated storage J Food SciTechnol 58:870–883.

Bae, S.M.; Cho, M.G. and Jeong, J.Y. (2017). Effects of Various Calcium Powders as Replacers for Synthetic Phosphate on the Quality Properties of Ground Pork Meat Products. Korean J. for Food Korean J. Food Sci. An., 37(3): 456-463.

Barbut, S. and Mittal, G.S. (1991). Phosphates and antioxidants as cryoprotectants in meat batters Meat Science. 3, 279-291.

Barbut, S. (2002). Meat Color and Flavor.Poult. Prod. Proc.: An Ind. Guide. CRC Press, New York, USA, 448–453.

Byun, J.S.; Min, J.S.; Kim, I.S.; Kim, J.W.; Chung, M.S. and Lee, M. (2003). Comparison of indicators of microbial quality of meat during aerobic cold storage. J Food Protect 66:3839–3843. https://doi. org/10.4315/0362 -028X-66.9.1733.

Casco, G.; Veluz, G.A. and Alvarado, C.Z. (2013). Savor-Phos as an all-natural phosphate replacer in water- and oil-based marinades for rotisserie birds and boneless-skinless breast. Poultry Sci., 82: 3236–3243.

Cashman, K.D. (2002). Calcium intake, calcium bio-availability and bone health. Br. J. Nutr 87 (Suppl. 2):S169–S177.

Chang, C.C.; Yang, J.H.; Chou, C.K. and Tseng, T. (2010). Effect of replacing pork lard with carrot and onion on the quality of chinese style sausage. J Agric. Assoc Taiwan, 11 (4): 374–386.

Cho, M.G.; Bae, S.M. and Jeong, J.Y. (2017). Egg shell and oyster shell powder as alternatives or synthetic phosphate: Effects on the quality of cooked ground pork products Korean J. Food Sci. Anim. Res. 37(4) 571.

Choi, J.S.; Lee, H.J.; Jin, S.K.; Lee, H.J. and Choi, Y.I. (2014). Effect of oyster shell calcium powder on the quality of restructured pork ham. Korean J. Food Sci. An., 34: 372–377.

Cofrades, S.; López-López, I.; Solas, M.T.; Bravo, L. and Jiménez-Colmenero, F. (2008). Influence of different types and proportions of added edible seaweeds on characteristics of low-salt gel/emulsion meat systems. Meat Sci., 79: 767–776.

Danile, A.; Jessica, A.W.; Vincenzina, C.; Ri ccardo, V.; Azzurra, A.; Tormd, N. and Paula, V. (2017). Making sense of the "clean label" trends: A review of consumer food choice behavior and discussion of industry implications. Food Research International 1, 58-71.

Demirci, Z.O.; Yilmaz, I. and Demirci, A.Ş. (2014) . Effects of xanthan, guar, carrageenan and locust bean gum addition on physical, chemical and sensory properties of meatballs. J. of Food Science and Technology, 51(1): 936-942.

Dendougui, F. and Schwedt, G. (2004). In vitro analysis of binding capacities of calcium to phytic acid in different food samples. European Food Research and Technology, 219, 409-415.

Ding, D.; Zhou, C.Y.; Ge, X.Y.; Ye, K.P.; Wang, P.; Bai, Y. and Zhou, G.H. (2020). The effect of different degrees of superchilling on shelf life and quality of pork during storage. Journal of Food Processing and Preservation, 44(4): e14394.

Dykes, G.A.; Coorey, R.; Ravensdale, J.T. and Sarjit, A. (2019). Phosphates. Encyclopedia of food chemistry. 218-224. Oxford: Academic Press.

E.S. (2005). Egyptian Standards of chicken and turkey meat products (2910/2005). Egyptian organization for standardization and Quality Control.

Edris, A.M.; Hemmat, M.I.; Shaltout, F.A.; Elshater, M.A. and Eman, F.M.I. (2012). Chemical analysis of chicken meat with relation to its quality. Benha Vet. Med. J., 23 (1): 87-93.

Egyptian Organization for Standardization "EOS" 63/10. (2006). Egyp. Organiz. For Standar. And quality control. Determination of Total Volatile Basic Nitrogen (TVB-N, mg%).

Egyptian Organization for Standardization "EOS" 63/9. (2006). Egyp. Organiz. For Standar. And quality control. Determination of Thiobarbituric Acid number (TBA, mg/Kg).

El-Shinawy, N.M. and Abdelmonem, M.A. (2020). Trials for replace industrial phosphate salts with milk calcium and guar gum powders as a natural product to improve the quality of minced beef. Animal Health Research Journal 2: 15-25.

FAO/WHO (2014). Food Security Indicators. FAO Statistics website (available at http://www) fao.org.

Grabitske, H.A. and Slavin, J.L. (2009). Gastrointestinal effects of low-digestible carbohydrates. Critical Reviews in Food Science and Nutrition, 49, 327–360.

Guerrero, L.I. and Hui YH. (2010). Handbook of Poultry Science and Technology, 2nd Proc., 2: PP.1-14.

Gupta, S. and Variyar, P.S. (2018). Guar gum: A versatile polymer for the food industry. Biopolymers for food design.Elsevier. Handbook of Food Bioengineering. 11, 383-407.

Jeong, J.Y. (2016). Alternative curing technology in meat products. Food Sci.Anim. Resour. Ind., 5: 77–84.

Jeong, J.Y. (2018). Determining the optimal level of natural calcium powders and whey protein concentrate blends as phosphate replacers in cooked ground pork products Korean J. Food Sci. Anim. Res. 38(6) 1246-52.

Jimenez, S.M.; Salsi, M.S.; Tiburzi, M.C.; Rafaghelli, R.C.; Tessi, M.A. and Coutaz, V.R. (1997). Spoilage microflora in fresh chicken breast stored at 4_C: influence of packaging methods. J ApplMicrobiol 83:613–618.

Jitoe, A.; Masuda, T.; Tengah, I.P.; Suprapta, D.N.; Gara, I.W. and Nakatan, N. (1992). Antioxidant activity of tropical ginger extract and analysis of the contained curcuminoids. Journal of Agriculture Food Chemistry. 40, 1337-1340.

Kilincceker, O.; Dogan, I.S. and Kucukoner, E. (2009). Effect of edible coatings on the quality of frozen fish fillets. LWT- Food Science and Technol. 42(4), 868-873.

Lee, J.J.; Park, S.H.; Choi, J.S.; Kim, J.H.; Lee, S.H.; Choi, S.H.; Choi, Y.I. and Jung, D.S. (2011). Effect of oyster shell powder on quality properties and storage stability of emulsion- type pork sausages. Korean J. Food Sci. Ani. Resour. 31, 469-476.

Liberty, J.T.; Dehghannya, J. and Ngadi, M.O. (2019). Effective strategies for reduction of oil content in deep-fat fried foods: A review. Trends in Food Science & Technology, 92, 172–183.

Long, N.H.B.S. and Gal R. Buňka (2011). Use of phosphate in meat products. African Journal of Biotechnology Vol. 10 (86), 19874-19882.

Maier, H.; Anderson, M.; Karl, C.; Magnuson, K. and Whistler, R.L. (1993). Chapter 8 –Guar, Locust Bean, Tara, And Fenugreek Gums. In R. L. Whistler & J. N. Bemiller (Eds.), Industrial Gums (Third Edition). Academic Press.

Mansour, E.H. and Khalil, A.H. (1999). Characteristics of low-fat beef burgers as influenced by various types of wheat fibres. Journal of the Science of Food and Agriculture, 79: 493-498.

Mikkelson, V.L. (1993). Hamburger Patty Technology: A Literature Review. Technical Report, Meat Industry Research Institute of New Zealand (Inc.), MIRINZ 932 ISSN 0465 -4390.

Mothershaw, A.S.; Gaffer, T.; Kadim, I.; Guizani, N.; Al-Amri, I.; Mahgoub, O. and Al-Bahry, S. (2009). Quality characteristics of broiler chicken meat on salt at different temperatures. Int. J. Food Propt., 12: 681-690.

Mudgil, D.; Barak, S. and Khatkar, B.S. (2014). Guar gum: Processing, properties and food applications—A review. Journal of Food Science and Technology, 51, 409–418.

Offer, G. and Trinick, J. (1983). On the mechanism of water holding in meat: The swelling and shrinking of myofibrils. Meat Sci., 8, 245–281.

Osheba, A.S. and Abd El-Bar, N. (2007). Effect of different marinating solutions on microbial growth inhibition and quality characteristics improvement of beef slices during cold storage. Egypt. Journal of Agriculture Research, 85: 629-646.

Park, K.S.; Choi, Y.I.; Lee, S.H.; Kim, C.H. and Auh, J.H. (2008). Effect of kappa-carrageenan and guar gum as a substitute for inorganic polyphosphate on pork sausages. Food Science and Biotechnology,١٧، ٧٩٤– ٧٩٨.

Porta, R.; Mariniello, L.; Pierro, P.; Sorrentino, A.; Giosafatto, V.; Marquez, G. and Esposito, M. (2012). Water barrier edible coatings of fried foods. Journal of Biotechnology and Biomaterials, 2, e116.

Raharjo, S. and Sofos, J.N. (1993). Methodology for measuring malonaldhyde as a product of lipid peroxidation in muscle tissues. J. Meat Sci. 35: 145- 169.

Reddy, B.G.V.; Sen, A.R.; Nair, P.N.; Reddy, S.K.; Reddy, K.K. and Kondaiah, N. (2013). Effects of grape seed extract on the oxidative and microbial stability of restructured mutton slices. Meat Science, 95: 288–294.

SCF "Guidelines of the Scientific Committee for Food" (2003). European Commission Scientific Committee on food. Health and food Safety. Report of the Scientific Committee on Food on the Revision of Committee Essential Requirements of Infant Formulae and Follow-on Formulae. Bruxelles Brussel, Belgium.

SCF "Guidelines of the Scientific Committee for Food" (2001). For the presentation of an application for safety assessment of a substance to be used in food content materials prior to its authorization. Bruxelles Brussel Belgium. http://Europa,eu. Int/Comm/food fs/sc/scf/index en.html.

Sebranek, J.G. (2009). Basic curing ingredients In: Tarte R., editor. Ingredients in meat products. Springer Science + Business Media LLC; NY. pp. 1–24.

Selgos, M.D. and Garcia, M.L. (2008). Technological strategies for functional meat products development trans world Research Network, Kerala, India.

Shand, P.; Sofos, J. and Schmidt, G. (1993). Properties of algin/calcium and salt/ phosphate structured beef rolls with added gums. Journal of Food Science, 58, 1224–1230.

Sindelar, J.J. (2015). Impact of removing functional non-meat ingredients in processed meat products and exploring possible alternatives. Proceed. 68th Recip. Meat Conf., Lincoln, NE, USA, pp. 48-51.th Recip. Meat Conf., Lincoln, NE, USA, pp. 42-46.

Soeparno (2009). Ilmudan Teknologi Daging. 4th ed (Gadjah Mada University Press, Yogyakarta).

Srichamroen, A. (2007). Influence of Temperature and Salt on Viscosity Property of Guar Gum, Naresuan University J., 15(2): 55-62.

Srinivasan, K. (2020). Cluster beans. Nutritional composition and antioxidant properties of fruits and vegetables. Elsevier.

**Tahmouzi, S.; Meftahizadeh, H.; Eyshi, S.; Mahmoudzadeh, A.; Alizadeh, B.; Molla-

khalili-Meybodi, N. and Hatami, M. (2023). Application of guar (Cyamopsistetr-agonolobaL.) gum in food technologies: A review of properties and mechanisms of action. Food Sci. Nutr., 11: 4869–4897.

Thangavelu, K.P.; Kerry, J.P.; Tiwari, B.K. and McDonnell, C.K. (2019). Novel processing technologies and ingredient strategies for the reduction of phosphate additives in processed meat. Trends Food Sci Technol 94:43-53.

Tolba, Khalid; Naglaa, A. ElTaib and Hanan, R.G. (2024). Trials for improving beef burger quality using some natural additives as alternatives to chemical phosphate. Europ. J. of Pharmaceu. And Med. Res. EJPMR, 11 (8): 317-325. ISSN 2394- 3211.

Tood, P.; Benfield, P. and Kl, G. (1990). Guar gum.A review of its pharmacological properties and use as a dietary adjunct in hypercholesterolemia. Drugs, 39:917–928.

Ulu, H. (2006). Effects of carrageenam and guar gum on the cooking and textual properties of low fat meatballs. Food Chemistry, 95, 600–605.

United States Department of Agriculture Food Safety and Inspection Service (USDA-FSIS) (2015). Safe and suitable ingredients used in the production of meat, poultry, and egg products. FSIS Directive 7120.1 Rev.31. USDA-FSIS, Washington, DC, USA.

US-FDA (2019). Code of Federal Regulations (SFR) Chapter 1- Food and Drug Administration. Department of Health and Human Services. Subchapter B. Food for human consumption. Title 21.Vol. 3.

Von Borries-Medrano, E.; Jaime-Fonseca, M.R. and Aguilar-Mendez, M.A. (2016). Starch–guar gum extrudates: Microstructure, physicochemical properties and in-vitro digestion. Food Chemistry, 194, 891–899.

Wang, X.H.; Deng, Y.H.; Sun, J.S.; Ding, Y.; Liu, Y. and Tian, T. (2022). Unraveling characterizations of bacterial community and spoilage profiles shift in chilled pork during refrigerated storage. Food Science and Technology, 42, e80321.

Whistler, R.L. and Be Miller, J.N. (1997). Carbohydrate Chemistry for food scientists. AACC, S. Paul.

Yadav, A.; Beura, C. and Prasad, N. (2013). Effect of guar gum and gum arabic addition on functional properties on the quality characteristics of chicken nuggets. Indian Journal of Poultry Science, 48, 58–62.

Yanti, H. and Hidayati, D.E. (2008). Kualitas daging sapi dengan kemasan plastik PE (polyethylen) dan plastik PP (polypropylen) Di pasar arengka kota pekanbaru. Jurnal Peternakan. 5: 22 – 27.

Yassin-Nessrien, M.N. and Abou Taleb, M. (2007). Antioxidant and antimicrobial effects of Marjoram and thyme in coated refrigerated semifried mull et fish fillets. World J. Dairy & Food Sci. 2 (1): 1-9.

Yoko, K. (2008). Guargum. Chemical and Technical assessment, the 69th JECFA. (CTA)2008,1-4.

Yoon, J.; Min, S.B Youn JJ. 2023. Effects of Nitrite and Phosphate Replacements for Clean-Label Ground Pork Products. Food Sci. Anim. Resour. 43:232-244.

Younes, M.; Aquilina, Ga.; Castle, L.; Engel, K.H.; Fowler, P.; Fernandez, M.J.F.; Furst, P.; Gurtler, R.; Husøy, T. and Mennes, W. (2019). Re-evaluation of phosphoric acid–phosphates – di-, tri- and poly phosphates (E 338–341, E 343, E 450–452) as food additives and the safety of proposed extension of use . EFSA J., 17, eo5674.

Yousif, M.; Mohamed, B. and Elkhedir, A. (2017). Physicochemical characterization of gum of some guar (Cyamposistetragono-lobaL. Taup) lines. Journal of Food Processing & Technology, 8, 2.

Zhang, L.M.; Zhou, J.F. and Hui, P.S. (2005). A comparative study on viscosity behavior of water-soluble chemically modified guar gum derivatives with different functional lateral groups. Journal of the Science of Food and Agriculture, 85, 2638–2644.