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EFFECT OF CHITOSAN ADDITION ON BURGER QUALITY AND SHELF LIFE

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ABSTRACT: Chitosan was used at different ratios (0.5, 1.0, 1.5 and 2.0%) in the processing of meet burger and studied effect on the physicochemical, color, organoleptic, and texture of burgers. The results showed that chitosan utilization in beef burger decreased total carbohydrate and increased moisture, protein, fat, fiber and ash content of the beef burger. Addition of chitosan at different levels decreased the water activity, cooking loss and pH value of burger compared to control burger. Increasing levels of chitosan increased water-holding capacity, cooking yield and shrinkage. Incorporation of chitosan to beef burger decreased L* values (lightness) and a* values (redness) while b* values (yellowness) increased. The addition of chitosan did not significantly affect any of the sensory scores tested. These results indicated that utilization of chitosan improved healthier profile without causing negative changes in physical, chemical and technological quality of burger. Texture profile analysis indicated that the maximum force required to compress the sample (hardness) was increased as the addition of chitosan to the burger. Addition chitosan in beef burgers showed no significant effect in deformation at hardness, adhesive force, resilience, stringiness length, cohesiveness, and springiness. Gumminess and chewiness declined as the addition of chitosan increased.

Key words: Chitosan powder, physicochemical properties, color, textural, sensory and evaluation.

INTRODUCTION

Fast food has become a significant component of the food industry in recent years. Burgers are very wellliked; their quality varies depending on their recipe. Many meat products are heavy in saturated fat and cholesterol and low in protein **(Campbell *et al*., 2017)**. There are numerous non-meat additives in use. The meat industry's most significant issue is how to create low-fat meat products without damaging their sensory and textural qualities (**Barbut *et al*., 2016**). Producing healthier beef products is challenging because they must be tasty and affordable (**Decker and Park, 2010; Fernández-Ginéz *et al*., 2005**).

Beef is defined as the meat of cattle used as food. The nutritional attributes of meat, which provide a major proportion of consumer requirements for protein, some vitamins and certain minerals, are highlighted in work on the nutritional value of meat in some countries (**Robinson, 2001**). Microbial growth and lipid oxidation are the two leading factors for quality deterioration of meat. Consumers demand high quality and convenient meat products, with natural flavour and taste, and they appreciate the fresh appearance of beef (**Hugas *et al*., 2002**). Colour is an important parameter that consumers use to judge the freshness and wholesomeness of beef. It has substantial influence on acceptability and purchasing decision at retail points (**Eikelenboom *et al*., 2000**). Oxidative processes, which occur during raw material storage, processing, heat treatment and further storage of final products, are major non-microbiological factors involved in quality deterioration of meat during refrigerated storage. Oxidation induces modifications of muscle lipids and proteins and, therefore, affects the organoleptic and nutritional properties of meat and meat products. This is reflected in economic losses and health disorders (**Insani *et al*., 2008; Karpinska *et al*.,**

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2001). Chitosan, which is mainly made from crustacean shells, is the second most abundant natural polymer in nature after cellulose (**Shahidi *et al*., 1999**). It is insoluble in most organic solvents and in water at neutral pH, but dissolves in dilute solutions of organic acids such as acetic, formic, tartaric, valeric, lactic, glycolytic and citric acids and also dissolves in dilute inorganic acids such as hydrochloric and sulfuric acids. Water insolubility of chitosan is disadvantageous for its wide application as an antibacterial agent (**Sashiwa and Aiba, 2004**). In the recent decades, extensive investigations have been carried out to prepare functional chitosan and to increase its solubility in water in order to broaden its application. It has been widely used as a natural food additive in the food industry due to its nontoxic nature, biocompatibility, antibacterial and film forming properties (**Majeti and Ravi, 2000**). Function of chitosan differs from its molecular weight and degree of deacetylation. The antimicrobial activity of chitosan with high molecular weight and high degree of de-acetylation was well documented against a number of food spoilage and pathogenic microorganisms with concentration varying from 0.5% to 1.5% (**No *et al*., 2002**). In meat industry one of the most important scientific areas for research and application of chitosan is the study of its antibacterial and antifungal properties as well as the development of protective coatings on the basis of this polysaccharide with myco-bacteriostatic or myco-bactericidal properties. Analysis of the properties of various chitosan grades has resulted in a working hypothesis that chitosan can be used as part of protective film-forming coatings for meat and meat products. Recently, interest has considerably increased in finding naturally occurring antioxidant for usage in foods in order to replace the synthetic antioxidants which are being restricted legitimately due to their side effects (**Guilcin *et al*., 2003**). In this research, chitosan as natural antioxidant will be used instead of synthetic antioxidant (BHA). Actually, chitosan has antioxidant and antimicrobial agents as well as to prolong the shelf life of meat and meat products. So far, we know that there is no research on preservation technique of beef at refrigerated temperature using chitosan in Bangladesh context. That's why the present work was conducted to fulfill the following objectives: i) to investigate the quality changes of beef at refrigerated temperature, ii) to evaluate the effect of chitosan on delaying lipid oxidation and iii) to evaluate the effect of chitosan on inhibiting microbial growth and extend the shelf life of beef. This study aimed to produce low-fat beef burgers by using chitosan in the formula of beef burgers without deteriorating the textural characteristics of burgers.

MATERIALS AND METHODS

Materials

All the ingredients needed to make the burgers, including raw beef, were bought from a nearby market (Dokki, Giza, Egypt). The Agricultural Research Center in Cairo, Egypt, provided the chicory roots and soy protein. Meanwhile, potato starch and sodium tripolyphosphate (Na5P3O10) were supplied from the Sigma-Aldrich Company (St. Louis, MO, USA).

Chitosan was Purchased from Sigma Company

Preparation of chitosan solution

To prepare 0.5%, 1%, 1.5% and 2% chitosan solutions respectively 2, 4, 6 and 8 gram chitosan was mixed with 4 ml glacial acetic acid and stirred until dissolved it. Then 150 ml distilled water was added with the mixture and stirred again until mixed properly. Finally the solution was made up to 300 ml with distilled water.

Preparation of beef burgers

Samples of beef burgers were made using a modified version of the technique outlined by **Aleson-Carbonell *et al*. (2005)**. 500 g of beef flesh was manually chopped with a JG-210 band saw before being minced on a 4 mm grinder plate. Minced beef (50g) was combined with salt (2% NaCl) for three minutes in a Hobart mixer. By a mixer, soy protein (50 g) and water were combined in a 1:5 (w/v) ratio and held between 2 and 5°C. (1%) Tri-polyphosphate sodium (0.25%), as stated in Table 1, paprika, spices (1% black pepper, 1% garlic powder, and 2%

onion powder), and 3% potato starch were combined with varying amounts of chitosan. According to the procedure outlined by **Zhanc *et al*. (2004)**, the cooked burgers were made by grilling in a Kenwood electric grill at power 10 for 7-8 min until the interior temperature reached 74 ± 1°C. The resulting mixture was formed into circular patties about 50 g in weight, 10 cm in diameter, and 0.5 cm thick. Before being packaged in polyethylene bags and stored, each item was isolated from the others using a polyethylene layer. The beef burger was divided into five equal portions for a different treatment as follows: T0: control beef burger sample, T1: sample of 0.5 % chitosan, T2: sample of 1.0 % chitosan, T3: sample of 1.5 % chitosan and T4: sample of 2.0 % chitosan. All treatments were packed in plastic bags and stored in a refrigerator at -20 ◦C for 90 days. Samples in three replicates from each batch were subjected to chemical and physical analyses initially and periodically after 3 months of frozen storage.

Physical tests

A Hanna pH 211 pH meter equipped with a Hanna FC 200B electrode was used to measure pH in each treatment (Hanna Instruments, Padova, Italy).

Water activity

The water activity analysis for the raw beef burgers was carried out using a water activity analyzer Novasina TH-500 (Novasina, Axair Ltd., Pfaeffikon, Switzerland) at 25◦C.

The water holding capacity

The water retention capacity was calculated as a percentage of the weight loss of a known-weight meat sample (**Zaky *et al*., 2020**).

Cooking loss

Cooking loss was calculated after draining the drip coming from the cooked meat as follows: Cooking loss (%) = $[(w_2-w_3) \div w_2] \times 100$; Where, w_2 = meat weight before cooking and w_3= meat weight after cooking.

Color measurement

The samples from both fresh and frozen storage underwent color measurement. X= 77.26, Y = -81.94, and Z = 88.14 (L* = 92.46, a* = -0.86, and b*=-0.16) were measured using a colorimeter (Lab. Scan XE, Hunter Lab., Murnau, Germany) and standardized with a white tile of Hunter Lab colour standard (LX No. 16379). L* (lightness), a* (redness), and b* (yellowness) were then measured as color parameters, and they were expressed as mean value standard deviation (**El-Faham *et al*., 2016**).

Texture analysis

Using a texture meter (Brookfield model-CT3-10 kg, USA) equipped with a cylinder Probe (TA-AACC36) for measuring burger firmness and carrying out texture profile analysis (TPA), the textural qualities of chilled (4 ± 1°C, 24 h) and grilled burger samples were assessed. TPA was used to measure various properties, including hardness, deformation at hardness, hardness work, adhesiveness, resilience, stringiness, cohesiveness, springiness, gumminess, and chewiness. The test speed was 2.00 mm sec, and the trigger load was 0.07 N. The analyzer was programmed to take two-cycle measurements to produce a two-bite texture profile curve. The tests were run on samples of hamburgers (10 mm x 90 mm depth x diameter). The results were reported as the averages of three burgers made in duplicate using each mixture.

Proximate composition

Moisture, crude protein, fat, ash contents, and total carbohydrates were calculated by differences and estimated using the methods described in **AOAC (2005)**.

Lipid oxidation

The 2-thiobarbituric acid (TBARS) assay was performed following **Rowayshed *et al*. (2015)**. For every treatment, two analyses were performed. A UVVIS spectrophotometer was used to measure the absorbance at 538 nm. TBA was calculated as mg of malonaldehyde per kilogram of the burger.

Sensory evaluation

According to **El-Sayed *et al*. (2020)**, fifteen trained panelists from the National Research Center's Food Technology Department (Dokki, Giza, Egypt) performed the sensory evaluation. Burger samples were judged on their color (20), flavor (20), tenderness (20), texture (20), appearance (20) and overall acceptability(100). Unless otherwise stated, $P<0.05$ was used to determine significance.

Statistical analysis

Using SPSS software, the study's data were subjected to a one-way analysis of variance (ANOVA) and significant differences (P <0.05) (2006). The results were calculated as the three duplicated samples' means.

RESULTS AND DISCUSSION

Chemical Composition of Burgers

The moisture, protein, ash, fiber, fat and carbohydrates contents of the cooked control and fortified burgers with different levels of chitosan (0.5, 1.0, 1.5 and 2.0 %) were cleared in Table 1. According to Table 1, formula samples with higher chitosan levels had higher moisture content and higher fat and protein content as compared to control samples. All the chemical components in beef burgers had minor variations. Results showed that the moisture, protein, ash, fiber and lipid content of control burger sample reached values of 42.18%, 60.77%, 7.91%, 2.72% and 10.28%, respectively. On the other hand, the addition of commercial chitosan to burger led to a slight significant increase (P≤0.05) in moisture content from 45.65% in T1 burger contain 0.5 % chitosan to 48.80% in burger contain 2% chitosan, respectively. In contrast, the moisture content of cooked burgers increased gradually as the percentage of chitosan increased. These results are similar to the findings of **Ucak *et al*. (2011), Cerón-Guevara *et al*. (2020) and Abdel-latif *et al*. (2021).** On the other hand, the cooking process caused significantly increases in fat content which may be related to the oil used in frying process. A like observation has been reported by **Dzudie *et al*.(2002)** for beef patties prepared with common bean flour and in buffalo meat patties prepared using different legume flours (**Modi *et al*., 2004**).

Effect of chitosan addition on water activity (aw) of uncooked burger

In reference to water activity (Fig. 1), the addition of chitosan to burgers an decrease (p < 0.05) in this parameter with respect to the control sample. This fact occurs due to that the addition of chitosan might reduce the vapor pressure of the food product, thereby reducing water activity (**Kezban and Nuray, 2003; Taormina, 2010; Abd Elgadir *et al*., 2015)**. Thus, the samples with higher chitosan content showed lower water activity. Generally, all values of aw were significantly (P<0.05) decreased as compared to the control. The decrease in aw could due to increasing in the concentration of infused organic acid. On the other hand, the addition of commercial chitosan to burger led to a slight significant decrease (P ≤ 0.05) in aw from 0.896 in (T1) burger contain 0.5 % chitosan to 0.811% burger contain 2% chitosan, respectively. In contrast, the water activity of uncooked burgers decreased gradually as the percentage of chitosan increased. The results obtained in this work corroborate those reported by **França *et al*. (2022)** in beef burgers with salt reduction added with shiitake by-products.

Effect of chitosan addition on moisture content of cooked burger

The beef burger's moisture content is a crucial component that influences the burger's quality. It affects the burger's weight change during shipping and storage, drip loss after thawing, weight loss and shrinkage during cooking, and juiciness and tenderness (**Mahmoud *et al*., 2017**). According to Fig. 2, the inclusion of chitosan in the formulation of beef burgers increased the moisture content, which reached 45.65 and 48.80%, respectively, in the burgers made with 0.5% chitosan or 2% chitosan. The moisture content of some fibers is linked to the sort and quantity of their polysaccharides; large particles are associated with open structures that enhance the properties of hydration and fat absorption capacity. This could demonstrate the fact that the addition of chitosan increased the moisture content because of its ability to bind water molecules and retain fat. With regard to a boost in moisture content, a similar outcome was stated by Similar to our results, **López-Vargas *et al*. (2014)** reported that, the moisture content fell with the addition of passion fruit albedo in raw and cooked burgers. However, **Zargar *et al*. (2014)** found significant increases in moisture percent of chicken sausages formulated with pumpkin pulp, that could be due to higher moisture present in the fresh pumpkin.

Table1. Gross chemical composition of beef burger with different levels with chitosan (% on dry weight basis)

Samples	Moisture	Protein	Ash	Crude fiber	Fat	T.C.
T0	42.18± 0.11	60.77± 0.15	7.91± 0.09	2.72± 0.03	10.28± 0.13	18.32± 0.18
T1	45.65± 0.09	60.75± 0.22	7.90± 0.07	2.75± 0.01	10.30± 0.15	18.30± 0.15
T2	46.90± 0.06	60.78± 0.13	7.92± 0.05	2.77± 0.05	10.31± 0.19	18.22± 0.22
T3	48.35± 0.04	60.80± 0.17	7.94± 0.11	2.79± 0.02	10.29± 0.10	18.18± 0.25
T4	48.80± 0.15	60.82± 0.25	7.95± 0.14	2.81± 0.07	10.32± 0.20	18.10± 0.22

Where: T0= control beef burger sample, T1= sample of 0.5 % chitosan, T2= sample of 1.0 % chitosan, T3= sample of 1.5 % chitosan, T4= sample of 2.0 % chitosan and T.C.=Total Carbohydrate

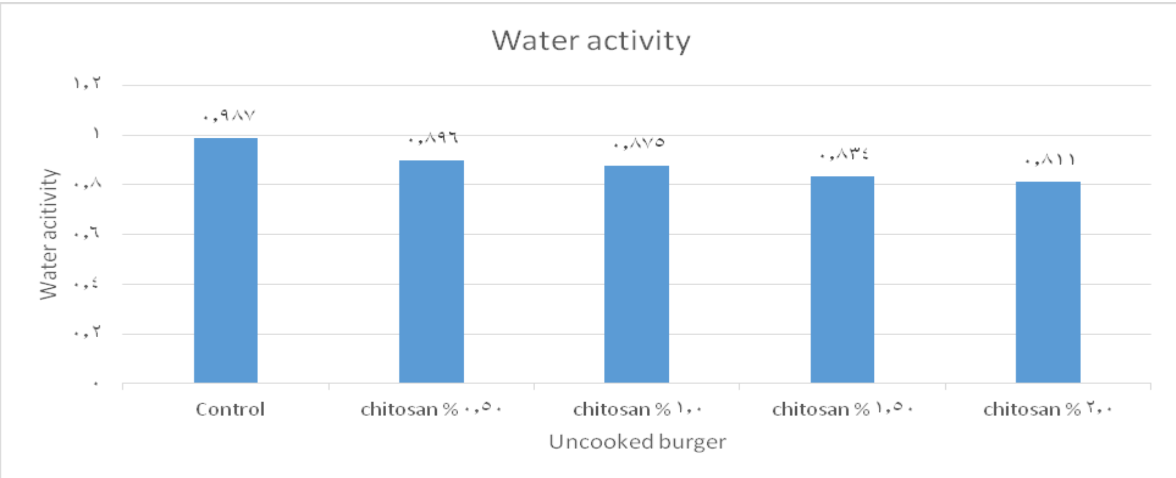

Fig.1. Effect of chitosan addition on water activity (aw) of uncooked burger

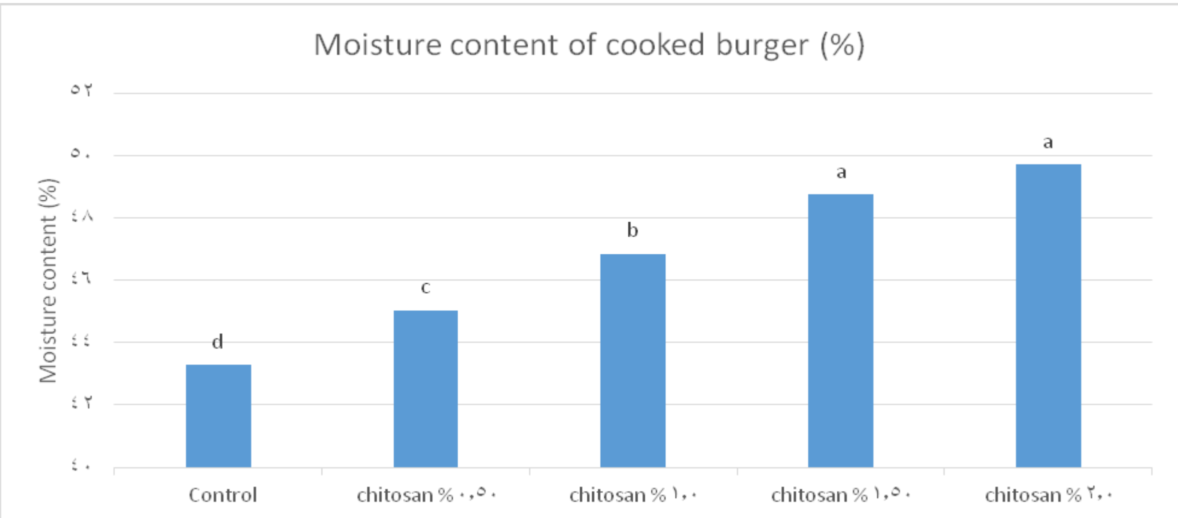

Fig. 2. Effect of chitosan addition on moisture content of cooked burger

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Color Measurements of Formulated Beef Burger

The effect of burger formulation with chitosan on color parameters at different concentrations is clearly shown in Table 2. L*, a* and b* values were within the range of 38.38-31.08, 8.52-14.14 and 9.66-12.38, respectively. The highest lightness value (L*) was found in the burger control (38.38). There was significant ($p < 0.05$) decreasing gradually in lightness as the percentage of chitosan increased in burger. The lowest lightness value (31.08) was recorded in the burger contained 2% chitosan. Lightness in food is related with many factors, including the concentration and type of pigments present (**Lindahl *et al*., 2001**). On the other hand, addition of chitosan in burger samples led to significantly lower ($p < 0.05$) the redness (a*) in concentration 2% when compared with control samples. a* values of the samples were significantly affected by the addition of chitosan ($p<0.05$), regardless of the added amount. That trend of decrement in a* values may be due to interference with the lipid oxidation in the myoglobin oxidation (**Selani *et al*., 2011**). On the other hand, the highest yellowness value (b*) was observed in the formulated burger with 2% chitosan (5.19), and the control sample recorded the lowest yellowness value (3.27). This result showed that utilization of 2% chitosan could cause a decrement in lightness and redness while increased in yellowness of the product compared to control samples.

PH Values of Burger

One of the main quality parameters of meat and meat quality is pH values which gives an indication of acid and alkalinity and pH is linked to all other quality parameters including colour changes, water holding capacity, texture and of course shelf life (**Abd-El-Qader, 2003; Simela, 2005 and Hashem *et al*., 2011).**). From the pH data presented in Fig. 3 it could be noticed that, the burger with added chitosan powder of different levels showed lower pH (5.94-5.68) comparing to control samples (pH 6.03). The results obtained in this study corroborate those reported by **Abd Elgadir *et al*. (2015)** in burger formulated from fresh beef cuts (*Longissmus dorsi*) infused with citric acid.

Effects of chitosan addition on cooking characteristics of burger

In meat products specially beef burger, cooking parameters are fundamental because it affects the consumers' acceptability through affecting quality and juiciness and furthermore, it affects nutritional value such as losing soluble vitamins and amino acids (**Sayas-Barberá *et al*., 2020**). Cooking properties like cooking loss, cooking yield and shrinkage are the most important attributes of meat products quality (**El-Seesy, 2000**). Cooking characteristics of the prepared beef burger with the addition of chitosan at different levels significantly ($p < 0.05$) improved as could be seen in Table 3. Shrinkage after beef burger cooking measures the differences between the burger diameter before and after cooking and it reflects the amount of water and fat separated from the burger. It can be a clue on the quality of protein and on the ability of burger matrix to hold fat and water (**Darwish *et al*., 2012**). For consumers' thinking and believes, shrinkage of burger might be linked to the addition of water to the burger recipe which is un-preferred (**Ragab *et al*., 2020**). From data in Table 3 it could be cleared that, addition of the chitosan was able to increase the shrinkage from its manimum value in control (14.28%) gradually to reach 27.35% in the 2% chitosan added to the burger.

Cooking loss of the chitosan added to the burger showed less cooking loss compared to control burger samples. At zero time maximum cooking loss was obtained by control burger samples (32.09%) while the addition of 2% of chitosan decreased cooking loss to be 17.52%. Decreased cooking loss might be because of the higher fiber contents in the chitosan dried powder which could retain more water and the antioxidant activity in dried powder. These findings comes in accordance to what was found by **Darwish *et al.* (2012)** who found that cooking loss decreased when thyme, rosemary marjoram and sage was added to chicken burger and author also reported an increased cooking loss after storage (**Darwish *et al*., 2012**). A positive influence in cooking yield was obtained by the addition of chitosan powder as it increased from 67.75% in control sample to reach 82.17% in the 2% chitosan dried powder

Table 2. Effect of chitosan on color parameters of cooked burger

Samples	Color parameters		
	L (Lightness)*	*a* (Redness)*	*b* (Yellowness)*
Control	38.38[a]	4.67[a]	3.27[d]
0.50% chitosan	37.23[a]	4.09[b]	4.39[c]
1.0% chitosan	35.38[a,b]	4.14[b]	4.67[b,c]
1.50% chitosan	32.38[b,c]	3.995[b]	4.96[a,b]
2.0% chitosan	31.08[c]	3.94[b]	5.19[a]
LSD at 0.05	3.262	0.457	0.441

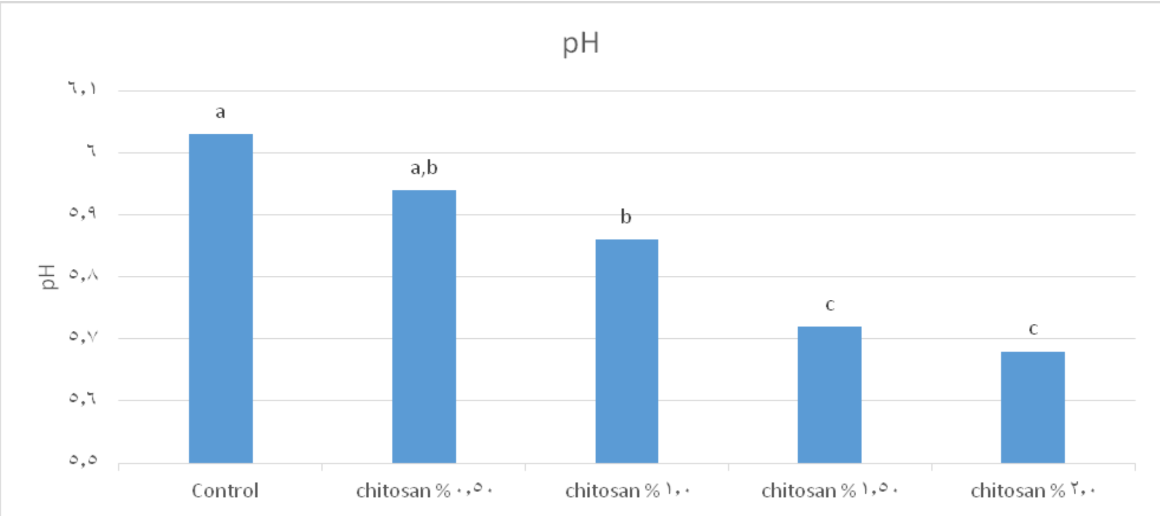

Fig. 3. Effect of chitosan addition onpH values of cooked burger

Table 3. Effect of chitosan on cooking quality parameters of cooked burger

Sample	Cooking quality of cooked burger			
	Shrinkage (%)	Cooking loss (%)	Cooking yield (%)	Water holding capacity (%)
Control	14.28[e]	32.09[a]	67.75[e]	34.24[d]
0.5% chitosan	17.09[d]	26.99[b]	72.38[d]	36.88[c,d]
1.0% chitosan	21.43[c]	24.02[c]	75.76[c]	37.75[c]
1.5% chitosan	24.41[b]	20.10[d]	79.35[b]	41.30[b]
2.0% chitosan	27.35[a]	17.52[e]	82.17[a]	44.72[a]
LSD at 0.05	1.344	1.668	1.960	2.870

added samples, respectively. The increase in cooking yield might be due to the existence of high amounts of fibre which is a hydrophilic constituents that adsorb water and form gels resulting in its retention in food system (**Cócaro *et al*., 2020**) in addition to the higher protein contents in the additives.

Water holding capacity is defined as the ability of meat and meat products to retain moisture and it is one of the most quality characteristics that decide the juiciness and quality of meat and meat products. Visual acceptability, weight loss, cooking characteristics and sensory traits depends on WHC of meat and meat products. Eating quality, tenderness, juiciness, thawing drip and cooking loss in meat and meat products are associated with the decrease of WHC (**Morsi, 1988**). It was reported that fibers of plant sources is strongly associated with the WHC and water swelling activity (**Zhang *et al*., 2020**). Table 3 presents the effects of the addition of chitosan dried powder to the burger formula on its WHC. Minimal WHC was noted in the control beef burger samples without the addition of chitosan powder with a score of 34.24%. Addition of chitosan showed a significantly ($p < 0.05$) higher WHC that was in the range of 36.88 – 44.72% which might be ascribed to the higher protein contents in these treatments. Maximal WHC was that of the 2 g/100g added chitosan powder with a score of 44.72.

Sensory Evaluation

Data of sensory properties of beef burger as affected by adding chitosan at different levels are listed in Table 4. Significantly ($P<0.05$) differences were observed in score values of color, flavor, tenderness, texture, appearance and overall acceptability among control sample (0% chitosan level) of burger and that contained 0.5, 1.0, 1.5 and 2.0% chitosan for all sensory characteristics. Sensory characteristics of samples beef burger prepared using chitosan up to 2% ratio had nearly similar scores in compared with those of control of beef burger. Using of chitosan at the concentration of more than 2.0% led to decrease the scores for sensory characteristics of beef burger. The decrements with 2.0% represent about 18.65, 18.90, 17.20, 18.65 and 15.22% of the control, that is mean all ratios of chitosan replacement can use for manufacture beef burger with overall acceptability more than 88.62% of the control. The highest values were noticed in beef burger contained 0.5% which was 18.75, 18.95, 18.75, 17.78, 18.61 and 92.84 for color, taste, tenderness, texture, appearance and overall acceptability, respectively; while lowest values were noticed in beef burger contained 2.0% level chitosan which were 16.70, 18.45, 16.75, 14.20, 15.66 and 81.76 compared to all samples. These results are in agreement with those obtained by **Soncu *et al.* (2015); Kılınççeker and Kurt (2016) and Gad (2019)**, who revealed that the decrease of appearance, color, flavor, texture and overall acceptability scores decreased with increasing levels of fiber. The obtained results are also particularly agreement with those of **Mwove *et al*. (2016) and El-Sayed *et al.* (2020),** who reported that the level of GA used in extended beef rounds significantly affected in all sensory attributes in cooked beef burger samples.

Texture Analysis

The texture of cooked meat is generally considered to be affected by heat-induced changes in connective tissue, soluble proteins and myofibrillar proteins (**Zayas and Naewbanij, 1986**). A texture profile examination of formulated burger samples containing 0.5, 1.0, 1.5%, and 2.0% chitosan was conducted and compared with the control burger sample. Table 5 showed that as chitosan addition to the burger increased the maximum force needed to compress the sample (hardness) of cycles 1 or 2 reduced, whereas the hardness of the stored burger rose in comparison to the same formulation sample without chitosan. Chitosan adding to beef burgers; however, there was no discernible difference in deformation at hardness, adhesive force, resilience, stringiness length, cohesiveness (a measure of how much the sample could be distorted before breaking), and springiness before or after cooking (the ability of the sample to recover its original form after the deforming force was removed). In comminuted meat products, textural properties are closely related to the functionality of muscle proteins and the presence of non-meat ingredients. The results of texture profile analysis of the uncooked burgers could be seen in Table 5. Hardness, springiness, cohesiveness,

Table 4. Effect of chitosan on sensory parameters of cooked burger

Sample	Sensory evaluationof cooked burger					
	Color (20)	Flavor (20)	Tenderness (20)	Texture (20)	Appearance (20)	Overall acceptability (100)
Control	18.65^{a}	18.90^{a}	$17.20^{c,d}$	18.65^{a}	15.22^{c}	$88.62^{b,c}$
0.50% chitosan	18.75^{a}	18.95^{a}	$18.75^{a,b}$	$17.78^{a,b}$	$18.61^{a,b}$	92.84^{a}
1.0% chitosan	17.85^{a}	18.75^{a}	19.15^{a}	16.85^{b}	19.23^{a}	$91.83^{a,b}$
1.50% chitosan	16.85^{a}	18.55^{a}	$17.90^{b,c}$	15.37^{c}	17.42^{b}	86.09^{c}
2.0% chitosan	16.70^{a}	18.45^{a}	16.75^{d}	14.20^{c}	15.66^{c}	81.76^{d}
LSD at 0.05	2.064	0.873	0.900	1.337	1.374	3.289

Control


0.5% Chitosan 1.0 % Chitosan


1.5% Chitosan 2.0% Chitosan

Table 5. Textural characterizations of the control sample and beef burger (uncooked)

Sample	Control	0.5% chitosan	1.0% chitosan	1.5% chitosan	2.0% chitosan
Hardness cycle 1 (N)	26.41	28.44	32.53	33.85	33.41
Deformation at hardness (mm)	6.37	6.37	6.40	6.40	6.39
Hardness work cycle 1 (mJ)	858	887	1333	1157	1290
Adhesive Force (N)	1.19	1.38	1.45	1.36	1.92
Adhesiveness (mJ)	133	121	174	125	160
Resilience	0.07	0.08	0.04	0.05	0.05
Stringiness Length (mm)	10.14	11.40	14.72	9.71	8.85
Stringiness work done (mJ)	93.00	85.00	155.00	93.00	106.00
Hardness cycle 2 (N)	22.57	24.59	27.99	29.25	28.81
Hardness work cycle 2 (mJ)	408.00	436.00	478.00	432.00	465.00
Cohesiveness	0.48	0.49	0.36	0.37	0.36
Springiness	6.21	7.64	6.38	21.60	19.86
Gumminess (N)	12.56	13.97	11.65	12.63	12.05
Chewiness (mJ)	795	1088	758	2782.00	2440.00

Table 6. Textural characterizations of the control sample and beef burger supplemented with different concentrations of chitosan (cooked)

Sample	Control	0.5% chitosan	1.0% chitosan	1.5% chitosan	2.0% chitosan
Hardness cycle 1 (N)	46.54	50.83	50.42	70.02	47.41
Deformation at hardness (mm)	5.00	5.00	4.99	5.00	4.99
Hardness work cycle 1 (mJ)	1224	18.10	18.10	22.80	18.40
Adhesive Force (N)	0.04	0.05	0.06	0.05	0.06
Adhesiveness (mJ)	0.00	0.00	2.00	0.0	2.00
Resilience	0.49	0.47	0.44	0.43	0.46
Stringiness Length (mm)	13.73	13.85	0.18	16.69	11.46
Stringiness work done (mJ)	0.00	0.00	0.00	0.00	1.00
Hardness cycle 2 (N)	44.22	47.90	47.45	64.98	44.89
Hardness work cycle 2 (mJ)	1104.00	1736.00	1120.00	1351.00	1084.00
Cohesiveness	0.90	0.83	0.80	0.79	0.83
Springiness	4.21	4.07	4.12	4.14	4.10
Gumminess (N)	41.99	42.41	40.57	55.21	39.43
Chewiness (mJ)	1803.00	1760	1704.00	2331.00	1648.00

gumminess and chewiness of the samples were between 26.41-33.41 N, 6.21-19.86, 0.48-0.36, 12.56-12.05 N and 795-2440, respectively. Most of the samples formulated with chitosan showed equivalent textural parameters to control samples without chitosan. While after cooking hardness, springiness, cohesiveness, gumminess and chewiness of the samples were between 46.54-70.02, 4.21-4.07, 0.90-0.79, 41.99-39.43 and 1803-2331, respectively. The obtained results are also particularly agreement with those of **LópezVargas *et al*.(2014), Bos-Sduza (2018) and Kamil *et al*. (2024).**

Conclusion

From previous results it could be concluded that, chitosan contain a high amount of dietary fiber and high percentage of phenolic compounds which act as antioxidant substances. The chemical composition of beef burger produced by adding chitosan revealed that, protein, ash, fat and dietary fiber contents were increased with increasing chitosan level, while total carbohydrate content was decreased. The adding chitosan to beef burger improved the physical properties of beef burger produced by increasing cooking yield and decreased cooking loss, shrinkage and diameter reduction. Cooking profile and sensory evaluation of beef burger showed that replacing level 0.5 and 1.0% gave values nearest to the control sample, also replacing levels 1.5 and 2.0% gave a fair product and not bad. So we can recommend using chitosan for production burger products for diabetic, obesity and hypercholestermic people.

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تأثيـــــر إضـــــافـــــــة الكيتـــوزان علـــى مـــــــدة صـــــــلاحيـــة وجـــودة البـرجـــر

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تم استخدام الكيتوزان بنسب مختلفة (0.5، 1.0، 1.5 و2.0%) في معالجة برجر اللحم ودراسة تأثيره على الخصائص الفيزيائية والكيميائية واللون والصفات الحسية والقوام للبرجر. أظهرت النتائج أن إضافة الكيتوزان إلى برجر اللحم البقري عززت زودت من محتواه من الرطوبة والبروتين والدهن والألياف والرماد مع تقليل مستوى نسبة الكربوهيدرات الكلية. أدت إضافة الكيتوزان بنسب مختلفة إلى تقليل معامل النشاط المائي وفقدان الطهي وقيمة الرقم الهيدروجيني للبرجر مقارنة بالبرجر العادي. أدت زيادة نسب الكيتوزان إلى زيادة سعة الاحتفاظ بالماء وإنتاجية الطهي والانكماش. أدى الكيتوزان المضاف إلى برجر اللحم البقري إلى انخفاض في قيم L * (اللون الفاتح) و a * (الاحمرار) بالإضافة إلى زيادة في b * (الاصفرار). لم يتأثر أي من الدرجات الحسية المقيمة بشكل كبير بإضافة الكيتوزان. أظهرت هذه النتائج أن إضافة الكيتوزان إلى البرجر عززت حسنت من مظهره الصحي دون تدهور جودته التكنولوجية أو الكيميائية أو الفيزيائية. ارتفعت أعظم قوة مطلوبة لسحق العينة تزداد الصلابة مع إضافة الكيتوزان إلى البرجر، وفقًا لتحليل ملف تعريف الملمس. لم تؤثر إضافة الكيتوزان إلى فطائر اللحم البقري بشكل كبير على التشوه عند الصلابة أو قوة الالتصاق أو المرونة أو طول الخيوط أو التماسك أو المرونة. مع إضافة المزيد من الكيتوزان، انخفضت في حين انخفضت اللزوجة والمضغ.

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