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Effect of sodium alginate on the quality of chicken sausages

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Abstract

The study was conducted to find out the effect of adding different levels of sodium alginate on the sensory, physicochemical, biochemical and microbiological properties of fresh and preserved chicken sausage. Chicken sausage samples were divided into three treatment groups: T_1 (Control group), T_2 (2% sodium alginate) and T_3 (4% sodium alginate). The sensory qualities like color, juiciness, tenderness and overall acceptability were increased with different treatment levels and decreased with increase of days of intervals. Dry matter (DM) content decreased significantly ($p<0.05$) with different treatment levels and increased with the enhancement of days of intervals. Crude Protein (CP) content decreased significantly ($p<0.05$) with different treatment levels and days of intervals. Ether extract (EE) content decreased significantly ($p<0.05$) with different treatment levels and decreased with the increase of the days of intervals. Ash content increased significantly ($p<0.05$) with different treatment levels and increased with the increase of days of intervals. At different treatment levels and days of intervals, cooking loss decreased and pH value increased. Free fatty acid (FFA), peroxide value (POV) and 2-thiobarbituric acid (TBA) value were decreased significantly ($p<.0.05$) with different treatment levels but enhanced with the increase of days of intervals. Microbial assessments like total viable count (TVC), total coliform count (TCC) were decreased significantly ($p<0.05$) with different treatment levels but increased with days of intervals and, total yeast mould count (TYMC) were decreased with different treatment levels and days of intervals. Therefore, 4% sodium alginate can be recommended as a source of antioxidant in chicken sausage.

Introduction

Meat products are the best sources of complete proteins, fats, essential amino acids, minerals and vitamins that are essential for optimal development and growth (Verbeke et al., 2010). Meat products such as sausages, meat patties, meat ball etc. are very popular because these products are delicious, nutritious, can be preserved for long time and so on (Akhter et al., 2022; Akter et al., 2022; Bithi et al., 2020; Boby et al., 2021; Disha et al., 2020; Islam et al., 2018; Khatun et al., 2022). It is well known that phycocolloids like alginates have significant water absorption and viscosity even at low concentrations, as well as being soluble in cold water. Alginates could be used as thickening agent in meat products and as sausage casings (Wylie, 1973). The texture of sausage was improved when 40 % of the meat was replaced with alginate fibers plus plasma protein isolate (Rusig, 1979). Considering the value of meat, different types of meat products are available in the market to meet consumers demand. Sausage is one of the most popular meat products. Sausages are emulsions of the oil in water type with protein as the emulsifier. It is essentially ground meat variously seasoned and cooked that mixed with different types of binders like oats, corn flour, jellying powder and spices. Wide variety of sausage were developed all across the world, with each location developing its own specific style of sausage based on local ingredients, spices, and casings (Ali et al., 2022; Hossain et al., 2021). Climate was another important factor for the development of region specific fresh and dry sausages. Among these, chicken sausages are very popular and widely found in the market. Although the production of sausage is not extensively practiced in our country, there is a lot of scope for development of sausage industry due to market availability of chicken meat.

Due to emerging and re-emerging health challenges, meat industry has created new pressures on the meat professionals to produce product with food safety issues and low-cost production. Health conscious consumers demand low level of fat and higher dietary fiber in meat products because the high saturated fat content of such products results in a restriction of consumption for those who are prone to cardiovascular diseases and/or suffer from overweight (Wyness et al., 2011). Thus, the challenge for meat industry is to develop low-fat meat products without compromising sensory and texture characteristics (Miller et al., 2009). People who follow a low-calorie and low-fat diet choose low-fat meats. Poultry meat is a good source of selenium, vitamin B3, B6 and choline. In order to develop different types of safe and healthy products like bioactive compounds, herbal extracts, compound jellying powder (sodium alginate) are added to increase the nutritional value of chicken sausage. The products supplemented with compound jellying powder (sodium alginate) can play an important role in the existing food crises besides its health claims. Compound jellying powder is a thermal irreversible gel. It increases the quality, elasticity and crispiness of chicken sausage (Thelen, 2014).). It holds oil and water and helps to make the products cut into slices easily. It increases the appearance, flavor, tenderness and overall acceptability of food products and reduces the cost. It keeps the least drip loss and increases the production rate of chicken sausage as well as being highly cost-effective. Based on the above discussion, the experiment was conducted to estimate the effect of sodium alginate on nutritive value of chicken sausages

Materials and Methods

Materials

Freshly slaughtered chicken meats (broiler) weighing 1.4 kg were obtained at 10 a.m. from Mymensingh town, Bangladesh.. The following ingredients were used for making sausage: Fresh chicken meat, garlic pest, onion pest, ginger pest, meat spices, garam masala, salt, sodium tripolyphosphate, ice flakes, sodium erythorbate, jellying powder (Sodium Alginate). Most these ingredients were obtained from the local market in Mymensingh, Bangladesh except for Sodium alginate (brand: Onlinesciencemall, USA), sodium erythorbate (brand: The sausage maker, USA), sodium tripolyphosphate (brand: Tata, India) which were collected from Dhaka, Bangladesh.

Preparation of Sausage

All visible fat and connective tissue were trimmed off as far as possible with the help of knife and the sample was cut into small pieces. Chicken meat was grinded with the help of 0.4-cm grinder plate (Super grinder-MK-G3; Matsushita Electric Industrial, Japan). The grinded meat was then mixed with some spices i.e. Chili powder, turmeric powder, condiments, fat, STPP. Minced meat was chopped in bowl chopper along with salt (2.5%), Sodium tripolyphosphate (0.25%). The meat was divided into 3 parts. Each part was then mixed with compound jellying powder (Sodium alginate) at 0%, 2% and 4% respectively. Meat from each mixture was then taken and was wrapped with small square pieces of plastic as a casing into candy like structure. Both ends were then tied with thread to check the entry of water and was then placed in to boiling water for cooking. These procedures were made for three times to prepare sample to analyze the first one as fresh basis. The temperature in bowl chopper was kept low by adding water in the form of slushed ice intermittently throughout the process.

Proximate Composition

Dry Matter (DM), Ether Extract (EE), Crude Protein (CP), and Ash were measured using the procedures described (AOAC, 1990).

pH Measurement

pH value of raw sausage was measured using pH meter. The homogenate was prepared by blending 20 g of sausage with 10 ml distilled water. pH value of cooked sausage was measured following the same procedures.

Cooking Loss

The fresh sausage samples were weighted (initial weight) and then boiled at water bath to 100ºC. Cooking loss was determined by the following formula:

Cook loss (%) = [(w2-w3) ÷ w2] x 100;

where w2 = meat weight before cooking and w3 = meat weight after cooking.

Assessment of Lipid Oxidation

Lipid oxidation was determined by the measurement of free fatty acid value, peroxide value, and TBA value. Free fatty acid value was determined according to (Rukunudin et al., 1998). Peroxide value (POV) was determined according tozo (AOAC, 1990). 2-thiobarbituric acid (TBA) value of the samples was assessed in triplicate using the procedure described by (Schmedes & Hølmer, 1989).

Microbial Evaluation

For microbial assessment, total viable count (TVC), total coliform count (TCC) and total yeast-mould count were undertaken. Sausage sample (10 g) was aseptically excised from stored stock sample and 90 mL 0.1% peptone water was poured into a sterile container to homogenize in a laboratory homogenizer (IKA T25 digital, Ultra-Turrax, Germany). As a result, the samples were diluted 1:10, and the standard method's instructions were followed to make different serial dilutions ranging from 10^{-2} to 10^{-6}. (ISO, 1995). TVC, TCC, and total yeast-mould count were determined using 0.1 ml of each ten-fold dilution on triplicate TVC, TCC, and total yeast-mould count were expressed as colony forming units per gram (CFU/g) of chicken sausage sample. The formula was:

CFU/gm = (number of colonies / (volume plated × total dilution))

Sensory Evaluation

Representative samples of the different sausage formulations were cooked in hot water at 75°C for 25 min (Sallam et al., 2004). A trained 6-member panel was tasked to determine color, smell, juiciness, tenderness, overall acceptability score at 0, 15 and 30 days of storage. Samples were introduced in uniform slices (3.5 cm in length) and served in covering petri dishes coded with 3-digit random numbers. Sensory evaluation was carried out in individual booth under control conditions of light, temperature and humidity and sensory grades ranged from 5 to 1, with 5 representing excellent, 4 representing very good, 3 representing good, 2 representing fair, and 1 representing bad (Rubio et al., 2006).

Statistical Analyses

All of the measurements were done in triplicate (n=3) and subsequent results were analyzed using analysis of variance (ANOVA) in SAS software (SAS Institute, 1990). The significance of variances between treatment means was determined using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Proximate Composition

Dry matter, ash content, crude protein, and ether extract of the sample shown in Table 1. At different treatments , the score ranges for DM, Ash, CP and EE were 27.36 to 27.85, 1.39 to 1.64, 27.71 to 27.96, and 2.32 to 2.58 respectively and days of interval for DM, Ash, CP, and EE were 15.16 to 33.80, 0.69 to 1.94, 28.59 to 30.56, and 2.12 to 2.77 respectively (Table 1). Ash increased significantly ($p<0.05$) on the other hand DM, CP and EE decreased significantly ($p<0.05$). The DM content and Ash were increased significantly ($p<0.05$) but CP and EE decreased significantly ($p<0.05$) with the increase storage period among these three observations. Among these three treatments, T_3 group had the most favorable DM content.The lowest DM content suggests that this product is the best choice.The DM content increased as the storage duration was extended because moisture loss reduced as the storage period was increased. Naveena et al. (2008) found that increasing the dry matter content of pomegranate peel extract and pomegranate rind powder extract increased the storage time. The most preferable ash content was observed from T_1 group. The lowest amount of ash content indicates this product is most preferable for consumers' health. The ash content was significantly increased with the increase storage period. The maximum level of ash content was increased to 1.94 % in all treatments after 30 days of storage, according to the findings. Konieczny et al. (2007) noticed a similar pattern, reporting that ash concentration increased during frozen storage. The lowest amount of CP content was observed from T_3 group. The CP content decreased as the storage period was extended. After 0 day, the most desirable CP material was found, whereas at 30 days, the least preferable CP content was found. Wheat bran (WB) and dried carrot pomace (DCP) included chicken sausage had considerably lower protein content (Yadav et al., 2018). Similar increasing trend in protein content with incorporation of whole egg powder was reported by Kalaikannan et al. (2007) and Verma et al. (2012) for chicken patties and chicken nugget respectively. The most preferable EE content was observed from T_3 group. The lowest amount of EE content indicates this product is most preferable for consumers' health. The EE content was decreased with the increase storage period. The data showed that the highest amount of EE content was increased to 2.77% in all treatments at o days of storage. Suradkar et al. (2013) also reported similar results in chicken nuggets. Eim et al. (2008) observed similar findings for dry fermented sausages made with carrot dietary fibers. Zargar et al. (2017). found that the ether extract concentration of the products decreased considerably ($p<0.05$) as the quantity of pumpkin integration in chicken sausages increased.

Table 1. Effect of Na Alginate on proximate component of chicken sausage

Parameters	DI	Treatments			Mean±SEM	Level of Significance		
		T_1	T_2	T_3		Treat.	DI	T*DI
DM%	0	33.91±0.16	35.35±0.33	36.22±0.04	35.16±0.17	0.4721	<0.0001	0.0044
	15	34.31±0.01	34.95±0.03	33.22±0.01	34.16±0.01			
	30	35.35±1.27	33.41±0.88	32.64±0.75	33.80±0.96			
	Mean±SEM	34.52^a±0.48	34.57^a±0.41	34.03^a±0.26				
ASH%	0	0.62±0.01	0.68±0.02	0.77±0.03	0.69±0.02	0.0519	<.0001	0.2169
	15	1.63±0.08	2.09±0.01	2.15±0.01	1.95±0.03			
	30	1.93±0.19	1.90±0.26	2.00±0.03	1.94±0.16			
	Mean±SEM	1.39^b±0.09	1.55^a±0.09	1.64^a±0.02				
CP%	0	27.65±0.10	35.52±0.20	28.53±0.10	30.69±0.20	<.0001	p<.0001	<.0001
	15	27.94±0.15	32.72±0.20	28.00±0.20	29.55±0.18			
	30	28.29±0.15	30.89±0.30	26.59±0.30	28.59±0.25			
	Mean±SEM	27.96^b±0.13	33.04^a±0.23	27.71±0.20				
EE%	0	2.61±0.01	3.03±0.09	2.68±0.09	2.77±0.06	0.0020	<.0001	0.0003
	15	2.56±0.08	2.90±0.15	2.50±0.17	2.65±0.13			
	30	2.58±0.07	2.00±0.05	1.78±0.04	2.12±0.05			
	Mean±SEM	2.58^a±0.05	2.64^a±0.09	2.32^b±0.10				

Here, DI = Days of Interval, DM = Dry Matter, CP = Crude Protein, EE = Ether Extract; Mean in each row having different superscript varies significantly at values $p<0.05$, T_1= control group, T_2= 2% Na Alginate, T_3=4% Na Alginate

pH and Cooking Loss

The pH of the different treatments in different time intervals was almost stable (Table 2). It is also obvious that the values of pH for the product were higher due to the interaction effect of the other ingredients which were added during the processing of meat products. While the range of overall observed pH at different treatments was 6.30 to 6.28, there were significant ($p<0.05$) decrease of pH for all corresponding treatments. The range of overall cooked pH in different days of intervals was 6.24 to 6.30, where pH decreased significantly ($p<0.05$) with the increase of storage period. As a result of the increase in free fatty acids caused by rancidity, the cooked pH values for all samples decreased however over time throughout the 30 days of storage. The mean pH was similar in all the groups on all the days of analysis. The T_3 group experienced the best cooking loss out of the three treatments. The range of overall observed cooking loss at different treatments and observed cooking loss in different days of intervals were 19.13 to 19.11% and 19.17 to 19.02% respectively. The cooking loss was decreased with the increase of storage duration considerably ($p<0.05$).

Table 2. Effect of Na Alginate on physiochemical properties of chicken sausage

Parameters	DI	Treatments			Mean±SEM	Level of Significance		
		T_1	T_2	T_3		Treat.	DI	T*DI
pH	0	6.29±0.01	6.31±0.01	6.32±0.01	6.30±0.01	0.5267	0.0108	0.7745
	15	6.31±0.01	6.31±0.01	6.31±0.01	6.31±0.01			
	30	6.24±0.05	6.21±0.04	6.27±0.02	6.24±0.03			
	Mean±SEM	$6.28^{a}\pm0.02$	$6.27^{a}\pm0.01$	$6.30^{a}\pm0.01$				
Cooking loss (%)	0	19.17±0.01	19.15±0.01	19.22±0.01	19.17±0.01	0.0002	<.0001	<.0001
	15	19.12±0.01	19.11±0.01	19.15±0.01	19.12±0.01			
	30	19.04±0.01	19.03±0.01	19.03±0.01	19.02±0.01			
	Mean±SEM	$19.11^{a}\pm0.01$	$19.09^{b}\pm0.01$	$19.13^{a}\pm0.01$				

Mean in each row having different superscript varies significantly at values $p<0.05$, T_1= control group, T_2= 2% Na Alginate, T_3=4% Na Alginate DI=Day Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals.

Sensory Evaluation

The observational score of color, flavor, tenderness, juiciness and overall acceptability at different treatments were 3.77 to 4.33, 4.11 to 4.43, 3.88 to 4.67, 3.77 to 4.33, and 3.88 to 4.33, respectively and days of interval for color, flavor, tenderness, juiciness and overall acceptability 3.66 to 4.55, 4.11 to 4.10, 3.55 to 4.55, 2.88 to 4.55, and 3.66 to 4.55, respectively (Table 3). Color, tenderness, juiciness, and overall acceptability had significantly increased ($p<0.05$) with different treatments and decreased significantly ($p<0.05$) with the increase of storage period. Flavor had increased insignificantly ($p>0.05$) with different treatments and decreased significantly ($p<0.05$) with the increase of storage period. Among three treatments most preferable color was observed from T_3 and less preferable color was observed from the control group. The lowest test score was reduced to 3.66 in all treatments after 30 days of storage, according to the results. Pigment and lipid oxidation, resulting in non-enzymatic browning between lipids and amino acids, might explain the gradual reduction in appearance and color scores of sausages held at -20^{o}C. The decreased color test scores during storage may resulted from the denaturation of proteins, particularly the myofibrillar protein that affects gel formation. The most preferable flavor was observed from T_3 group and the lowest flavor from T_1 (control group). the quality was deteriorated with the increase storage period. The lower flavor scores may be related to the increased malonaldehyde formation due to oxidation of fat, which has detrimental effect on the flavor and firmness of the product. Tenderness was found to be most desirable in the T3 group and least favorable in the control group among the three treatments. Tenderness was shown to be the most desirable at 0 days and the least favorable at 30th days. When sausages were frozen, ice crystals form inside the cells of muscle tissue and puncture the cell walls. That's why sausages leak moisture when they were cooked. Tenderness is interrelated DM content of the sausages. With the increasing of storage period DM was increased consequently tenderness was decreased with days intervals. The result of this experiment is related to Liu et al. (2010). Similar results were also reported by Marshall et al. (2005) and McMillin (2008). Further the similar findings were supported by Syuhairah et al. (2016). Among three treatment groups, most preferable juiciness score was observed at T_3 group and less preferable juiciness was observed at control group. The most preferable juiciness was observed at 0 day and less preferable juiciness at 30th days. The results were in accordance with findings of Raja et al. (2014), Chidanandaiah et al. (2009). The juiciness scores of several beef products decreased during refrigerated storage, according to Thomas et al. (2006). Most preferable overall acceptability was observed at T_3 group and less preferable at control group among three treatments but there were no significant ($p>0.05$) differences between these two days observation but different superscripts was observed from 30th days observation.

Table 3. Effect of Na Alginate on sensory parameters of chicken sausage

Parameters	DI	Treatments			Mean±SEM	Level of significance		
		T_1	T_2	T_3		Treat.	DI	T*DI
Color	0	4.33±0.33	4.67±0.33	4.67±0.33	4.55±0.33	$p<0.01^{**}$	$p<0.01^{**}$	$p>0.10^{NS}$
	15	3.67±0.33	4.00±0.58	4.33±0.33	3.77±0.41			
	30	3.33±0.33	3.67±0.33	4.00±0.58	3.66±0.41			
	Mean±SEM	3.77±0.33	4.11±0.41	4.33±0.41				
Flavor	0	4.33±0.33	3.67±0.33	4.67±0.33	4.11±0.33	$p>0.10^{NS}$	$p<0.01^{**}$	$p>0.10^{NS}$
	15	4.33±0.33	3.61±0.33	4.33±0.33	4.09±0.33			
	30	3.67±0.33	4.33±0.33	4.31±0.33	4.10±0.33			
	Mean±SEM	4.11±0.33	3.87±0.33	4.43±0.33				
Tenderness	0	4.33±0.33	4.67±0.33	4.67±0.33	4.55±0.33	$p<0.01^{**}$	$p<0.01^{**}$	$p>0.10^{NS}$
	15	4.00±0.00	4.00±0.00	4.33±0.33	4.11±0.11			
	30	3.33±0.33	3.67±0.33	3.67±0.33	3.55±0.33			
	Mean±SEM	3.88±0.22	4.11±0.22	4.22±0.33				
Juiciness	0	4.33±0.33	4.67±0.33	4.67±0.33	4.55±0.33	$p<0.01^{*}$	$p<0.01^{**}$	$p>0.27^{NS}$
	15	4.67±0.33	4.33±0.33	4.00±0.58	4.33±0.41			
	30	2.33±0.33	3.00±0.00	4.33±0.33	2.88±0.22			
	Mean±SEM	3.77±0.33	4±0.22	4.33±0.41				
Overall acceptability	0	4.33±0.33	4.67±0.33	4.67±0.33	4.55±0.33	$p<0.01^{**}$	$p<0.01^{**}$	$p>0.98^{NS}$
	15	4.00±0.00	4.33±0.33	4.33±0.33	4.22±0.22			
	30	3.33±0.33	3.67±0.33	4.00±0.00	3.66±0.22			
	Mean±SEM	3.88±0.22	4.22±0.33	4.33±0.22				

Sensory scores were 5 for excellent, 4 for very good, 3 for good, 2 for fair, and 1 for poor. Mean in each row having different superscript varies significantly at values $^{*}p<0.05$. Again, mean values having same superscript in each row did not differ significantly at $p>0.05$, T1=control group, T_2=2% Na alginate, T_3= 4% Na Alginate, DI=Days of Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals.

Table 3. Effect of Na Alginate on sensory parameters of chicken sausage

Parameters	DI	Treatments			Mean±SEM	Level of significance		
		T_1	T_2	T_3		Treat.	DI	T*DI
Color	0	4.33±0.33	4.67±0.33	4.67±0.33	4.55±0.33	$p<0.01^{**}$	$p<0.01^{**}$	$p>0.10^{NS}$
	15	3.67±0.33	4.00±0.58	4.33±0.33	3.77±0.41			
	30	3.33±0.33	3.67±0.33	4.00±0.58	3.66±0.41			
	Mean±SEM	3.77±0.33	4.11±0.41	4.33±0.41				
Flavor	0	4.33±0.33	3.67±0.33	4.67±0.33	4.11±0.33	$p>0.10^{NS}$	$p<0.01^{**}$	$p>0.10^{NS}$
	15	4.33±0.33	3.61±0.33	4.33±0.33	4.09±0.33			
	30	3.67±0.33	4.33±0.33	4.31±0.33	4.10±0.33			
	Mean±SEM	4.11±0.33	3.87±0.33	4.43±0.33				
Tenderness	0	4.33±0.33	4.67±0.33	4.67±0.33	4.55±0.33	$p<0.01^{**}$	$p<0.01^{**}$	$p>0.10^{NS}$
	15	4.00±0.00	4.00±0.00	4.33±0.33	4.11±0.11			
	30	3.33±0.33	3.67±0.33	3.67±0.33	3.55±0.33			
	Mean±SEM	3.88±0.22	4.11±0.22	4.22±0.33				
Juiciness	0	4.33±0.33	4.67±0.33	4.67±0.33	4.55±0.33	$p<0.01^{*}$	$p<0.01^{**}$	$p>0.27^{NS}$
	15	4.67±0.33	4.33±0.33	4.00±0.58	4.33±0.41			
	30	2.33±0.33	3.00±0.00	4.33±0.33	2.88±0.22			
	Mean±SEM	3.77±0.33	4±0.22	4.33±0.41				
Overall acceptability	0	4.33±0.33	4.67±0.33	4.67±0.33	4.55±0.33	$p<0.01^{**}$	$p<0.01^{**}$	$p>0.98^{NS}$
	15	4.00±0.00	4.33±0.33	4.33±0.33	4.22±0.22			
	30	3.33±0.33	3.67±0.33	4.00±0.00	3.66±0.22			
	Mean±SEM	3.88±0.22	4.22±0.33	4.33±0.22				

Sensory scores were 5 for excellent, 4 for very good, 3 for good, 2 for fair, and 1 for poor. Mean in each row having different superscript varies significantly at values $^*p<0.05$. Again, mean values having same superscript in each row did not differ significantly at $p>0.05$, T1=control group, T_2=2% Na alginate, T_3= 4% Na Alginate, DI=Days of Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals.

Assessment of Lipid Oxidation

The ranges for TBA, FFA, and POV value at different treatment were 0.11 to 0.13, 0.02 to 0.03, and 2.10 to 2.17 respectively and for days of interval TBA, FFA, and POV value were 0.10 to 0.13, 0.01 to 0.05, and 1.94 to 2.36 respectively (Table 4). TBA, FFA, and POV value of all treatment decreased significantly ($p<0.05$) but for days of interval increased significantly ($p<0.05$). Most preferable TBA value was observed from T3. Lowest amount of TBA value indicates the product is most preferable for consumers' health. During the refrigerated storage period, TBA values increased significantly ($p<0.05$). With an increase in storage duration, Yadav et al. (2018) observed a significant increase in TBA value of control and fiber enriched sausage. At the 0th day, the most preferable FFA value was observed, whereas at the 30th day, the least preferable FFA value was recorded. The FFA value that was shown to be the most preferred was in the T3 group. When compared to the control group, the treated sample had a reduced FFA content. Alkass et al. (2013) found significant increase in FFAs with increasing storage time, which was comparable to the current study. Growth of lipolytic bacteria might explain the significant ($p<0.05$) increase in FFA content of the products during storage (Das et al., 2008). FFAs are formed when lipids are degraded by enzymes or bacteria. It gives information about stability of fat during storage. Most preferable POV was observed at T_3 group. Lowest amount peroxide value indicates this product is most preferable for consumers' health. During storage, POV increased in all treatments. Other studies have also reported an increasing peroxide value over storage time in products with or without antioxidants. However, antioxidant treatments, generally, can minimize the peroxide value in the food sample during storage compared with the control. Sallam et al. (2004) reported that an initial peroxide value of 6.32; however, after 21 days of storage, peroxide values ranged from 4.92 to 5.22 in fresh garlic-formulated samples to 4.68–5.91 in garlic powder samples, 5.74–6.88 in garlic oil samples and 5.21 in BHA formulated samples. There was positive and significant interaction between treatment and days of interval for TBA, FFA, and POV value.

Table 4. ffect of Na Alginate on lipid oxidation in chicken sausage

Parameters	DI	Treatments			Mean±SEM	Level of Significance		
		T_1	T_2	T_3		Treat.	DI	T*DI
TBARS (mg-MDA/kg)	0	0.12±0.01	0.11±0.01	0.11±0.01	0.10±0.01	<.0001	<.0001	<.0001
	15	0.15±0.01	0.11±0.01	0.10±0.01	0.10±0.01			
	30	0.13±0.01	0.13±0.01	0.14±0.01	0.13±0.01			
	Mean±SEM	0.13^{c}±0.01	0.12^{b}±0.01	0.11^{a}±0.01				
FFA (%)	0	0.01±0	0.01±0	0.02±0	0.01±0	<.0001	<.0001	<.0001
	15	0.05±0	0.01±0	0.01±0	0.02±0.01			
	30	0.01±0	0.05±0	0.05±0	0.05±0			
	Mean±SEM	0.03^{c}±0	0.02^{c}±0	0.02^{c}±0				
POV (meq/kg)	0	1.94±0.01	1.95±0.01	1.94±0.01	1.94±0.01	<.0001	<.0001	<.0001
	15	2.23±0.01	2.06±0.02	2.01±0.01	2.02±0.01			
	30	2.34±0.01	2.39±0.02	2.37±0.01	2.36±0.01			
	Mean±SEM	2.17±0.01	2.13±0.01	2.10±0.01				

Here, TBA = 2-thiobarbituric Acid, FFA = Free Fatty Acid, POV = Peroxide Value; Mean in each row having different superscript varies significantly at values $p<0.05$, T_1= control group, T_2= 2% Na Alginate, T_3=4% Na Alginate DI=Day Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals

Microbiological Assessment

The ranges for TVC, TCC and TYMC at different treatment were 5 to 6, 4.34 to 4.38 and 5.14 to 5.22 respectively and for days of interval TVC, TCC and TYMC were 5.27 to 5.58, 4.20 to 4.30 and 5.16 to 4.97 respectively (Table 5). TVC in the T_1 group (7.00 logCFU/g) was significantly ($p<0.05$) higher than the treated samples. The less amount of TVC value indicates this product is most preferable for consumers health (T_3 group). The amount of TVC was increased with the increase of storage period. The antioxidant compounds blocked the deteriorating of fat and helped prevent the metabolism of fat by bacteria. As a result, bacterial growth was lower in chicken sausages treated with Na Alginate. However, a number of studies have demonstrated that compounds existing in many spices also possess antimicrobial activity (Zhang et al., 2009). Mixtures of cinnamon (*Cinnamomum verum*) and clove (*Syzygium aromaticum*) oil were able to suppress the growth of major spoilage microorganisms in intermediate moisture foods (Li et al., 1998). The total coliform count (TCC) in the control sample (4.38 logCFU/g) was significantly ($p<0.05$) higher than in the treated samples among three treatments. The less amount of TCC value indicates the product is most preferable for consumers health. The amount of TCC was increased with the increase of storage period. Similar findings were observed by Singh & Immanuel (2014) of raw chicken meat emulsion incorporated with clove powder, ginger and garlic paste at refrigerated storage (4±1ºC). The antioxidant compounds blocked the deteriorating of fat and helped prevent the metabolism of fat by bacteria. Reddy et al. (2017) observed a significantly ($P<0.05$) lower coliform count in chicken meat patties incorporated with natural antioxidant extracts i.e., rosemary (RE) and green tea (GTE). The total yeast-mold count (TYMC) in the control sample (5.22logCFU/g) was significantly ($p<0.05$) higher than in the samples treated with sodium alginate among three treatments. The less amount of TYMC value indicates the product is most preferable for consumers' health. During storage TYMC value was decreased. Plant EOs were seen to be effective antimicrobial agents against food-borne infections and spoilage microorganisms in meat by certain researches (Busatta et al., 2008; Carraminana et al., 2008)

Table 5. Effect of Na Alginate on different microbe's population in chicken sausage

Parameters	DI	Treatments			Mean±SEM	Level of Significance		
		T_1	T_2	T_3		Treat.	DI	T*DI
TVC(log CFU/g)	0	5.40±0.03	5.30±0.02	5.10±0.03	5.27±0.02	0.0031	<.0001	0.7820
	15	5.61±0.04	5.45±0.01	5.25±0.02	5.43±0.02			
	30	5.75±0.06	5.60±0.03	5.40±0.04	5.58±0.04			
	Mean±SEM	5.58^a±0.04	5.45^b±0.02	5.25^b±0.03				
TCC(log CFU/g)	0	4.29±0.02	4.09±0.02	4.23±0.04	4.20±0.02	<.0001	<.0001	<.0004
	15	4.56±0.01	4.40±0.01	4.40±0.01	4.45±0.01			
	30	4.31±0.02	4.20±0.01	4.39±0.01	4.30±0.01			
	Mean±SEM	4.38^a±0.01	4.23^c±0.01	4.34^b±0.01				
TYMC(log CFU/g)	0	5.02±0.01	5.10±0.03	5.01±0.01	5.16±0.01	<.0001	<.0001	0.0047
	15	5.42±0.02	5.28±0.01	5.23±0.02	5.31±0.01			
	30	5.22±0.02	4.89±0.03	5.18±0.02	4.97±0.02			
	Mean±SEM	5.22^a±0.01	5.09^b±0.02	5.14^c±0.02				

Here, TVC = Total Viable Count, TCC = Total Coliform Count, TYMC = Total Yeast-Mould Count; Mean in each row having different superscript varies significantly at values $p<0.05$, T_1= control group, T_2= 2% Na Alginate, T_3=4% Na Alginate DI=Day Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals.

Conclusion

From the study it can be concluded that sodium alginate provides necessary antioxidants and improves overall nutritive and antimicrobial quality of chicken sausage while the effects are concentration dependent. Chicken sausage can be preserved for at least 30 days using 4% level of sodium alginate. On the basis of laboratory analysis, 4% sodium alginate was more acceptable and therefore it can be recommended for formulation of value-added chicken sausage as a source of enriched antioxidant and also as a natural polysaccharide.

Conflicts of Interest

The authors declare no potential conflict of interest.

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