Effect of calcium alginate coating on shelf life of frozen lamb muscle

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ABSTRACT

Considering the potential benefits of edible coatings and films for storage of food materials, effect of edible calcium alginate film on shelf life of frozen lamb muscles was studied in the present research. Microbial analyses including total microorganisms count and psychrophilic bacteria count and chemical analyses such as total volatile nitrogen (TVN) and moisture content determination were performed. Coated and uncoated samples had not statistically significant difference in total microbial count, total volatile nitrogen level and moisture content. However, there was statistically significant difference between the coated and uncoated samples in terms of psychrophilic bacteria count ($p<0.05$). Considering the role of psychrophilic bacteria in meat spoilage, results of the current research confirmed that calcium alginate films may be to some extent effective in shelf life extension of frozen lamb muscle.

Keywords: Calcium-alginate; Edible coating; Frozen lamb muscle; Shelf life

INTRODUCTION

Food packaging preserves quality and safety of products from time of production to time of consumption. Plastic materials have been used for packaging in food industry for over 50 years. There are environmental concerns over disposal of nonrenewable food packaging materials such as plastics. Additionally, plastic materials are derived from expensive petroleum products and use of these materials in food industry is not cost-effective. Therefore, edible coatings and films from proteins, polysaccharides and lipids are utilized in packaging industry [1].

By making progress in edible coating and film technology, most studies have been focused on composite edible films which have advantages of each ingredient. For example, an edible film based on protein and lipid, has the benefits of both materials [2-6]. General capacities of edible coatings and films include control of water vapor and gas transfer, preservation of volatile aromatic compounds, additive carriage and reduction of microbial load. Therefore, edible coatings and films have potential benefits for food packaging, especially fresh and frozen meat. They prevent saleable weight loss of products and texture changes by decreasing moisture loss during fresh and frozen meat storage. Furthermore, edible coatings could hold in juices, prevent dripping and maintain nutrients. Consequently, they eliminate the need for absorbent pads at the bottom of packages. Transfer of gases such as oxygen and carbon dioxide affects food stability and primary spoilage condition in many foods results from oxidation of lipids, vitamins, aromatic compounds and pigments; therefore, edible coatings and films reduce lipid oxidation, myoglobin oxidation and microbial loads of proteins and meat by controlling permeability of oxygen and carbon dioxide. Volatile flavor loss from, and foreign odor pick-up by coated products could be reduced. As a result, products' odor and flavor changes are prevented [1,7,8]. Calcium alginate coated lamb carcasses were significantly ($p<0.05$) lower in 24-hr shrinkage loss than those of the controls and total surface microbial counts from the sirloin area indicated a significant ($p<0.05$) reduction on days 5 and 7 [9]. In another investigation, edible calcium alginate coating had not significant inhibitory effect on the rate of coliforms growth and total microbial count of beef pieces; however, it significantly decreased shrinkage loss of the coated steaks [10]. According to the results of another study, calcium alginate coating containing different antioxidants, extends the shelf life of *Megalobrama amblycephala* during 21 days of storage at 4±1^{o}C [11]. Effectiveness of calcium-alginate for quality and shelf life improvement of meat has been confirmed in previous studies [12-17]. Although few researches have been conducted on the frozen alginate coated fish and pork [15-17] the alginate coating effect on frozen lamb muscle has not yet been studied. Considering that lamb cuts and lamb muscles are mostly commercialized as frozen meat and the high level of lamb meat consumption in the Middle East, especially Iran, the current research was performed for the evaluation of edible calcium alginate coating on shelf life of frozen lamb muscle.

MATERIALS AND METHODS

Coating solution preparation

The following coating solutions were used: Solution I (sodium alginate (5 gr), maltodextrin (45 gr), glycerol (20 gr) and distilled water (210 ml)), Solution II (calcium chloride (2.75 gr), carboxymethyl cellulose (0.9 gr) and distilled water (49 ml)).

Sample preparation

Fresh lamb muscle packages were purchased from Zarin Goosht-Jam Company. All the muscle packages were stored in the refrigerator until being tested. After preparing the solutions, all the muscle samples were taken out of the packages and with completely randomized design were assigned to coated and control (uncoated) groups. In the present study, immersion coating method was used.

Each muscle was immersed in solution I for approximately 1 min. After taking out of the solution, it was reimmersed for 1 min in order to have a uniform layer of coating on the muscle's surface. Then it was kept out and allowed to drip free of excess solution for about 2 min, followed by immersion in solution II for 1 min. The coated samples were dried at room temperature of 23± 2 ^{o}C and relative humidity of 50%±5 for 15 min. Then, the coated muscles were placed in disposable dishes and every dish was protected by a cellophane thin layer. The remaining uncoated muscles were considered the controls. Packaging of the control and coated samples were the same, except for the control packages which contained absorbent pads in order to become exactly the same as the muscle packages being sold in the market. Both coated and uncoated samples were kept at -18^{o}C and analyzed after 1, 4 and 8 weeks.

Microbiological analyses

Sampling, sample preparation, dilution preparation, enumeration of total microorganisms and enumeration of psychrotrophic bacteria were conducted according to Iran's National Standards No.690, No.691, No. 8923-1, No. 5272 and No. 2629 [18-22], respectively.

Chemical analyses

Total volatile nitrogen (TVN) and moisture content were determined according to the AOAC 928.08 method [23] and Iran's National Standard No. 745 [24], respectively.

Statistical analysis

The lamb muscle pieces were randomly assigned for control and coating treatments.

The experiments were performed in triplicates and the data were analyzed using a 4(storage intervals 0, 1, 4 and 8 weeks) × 2 (treatments) completely randomized factorial design by the general linear model (GLM) procedure of a SPSS Statistical Program, version 15.0, Chicago, IL, USA to assess means of 4 variables (Total microbial count, Psychrophilic bacteria count, TVN and moisture). The data were expressed as mean±standard deviation (SD). If differences existed among the samples, the differences were compared by bonferonie adjustment at the level of $p<0.05$.

RESULTS

Microbial characteristics

Mean of total microbial count for the coated and uncoated muscle samples during 0, 1, 4 and 8 weeks of storage at -18^{o}C are displayed (Table 1). According to the results of Analysis of Variance, there was no significant difference in total microbial count between the coated and uncoated muscle samples Mean of total microbial count of the coated and uncoated muscle samples significantly decreased from 5.33 logCFU/g and 5.47 log CFU/g on week 0 to 1.49 logCFU/g and 1.43 logCFU/g on week 1, respectively (p<0.05) (Table 1). Mean of psychrophilic bacteria count for the coated and uncoated muscle samples during 0, 1, 4 and 8 weeks of storage at -18°C are displayed in (Table 1). According to the results of Analysis of Variance, there was significant difference in psychrophilic bacteria counts between the coated and uncoated muscle samples on weeks 4 and 8 (p<0.05) (Table 1). Mean of psychrophilic bacteria count of the coated and uncoated muscle samples significantly decreased from 5.75 logCFU/g and 6.12 logCFU/g on week 0 to 1.12 logCFU/g and 1.14 logCFU/g on week 1, respectively (p<0.05) (Table1).

Table 1. Microbial and chemical properties (Mean ± SD) of lamb muscle samples stored at freezing (-18°C) temperature according to coating status and storage time

Variable	Treatment	Storage Time (Weeks)			
		0	1	4	8
TMC[a] (log CFU/g)	Coated	5.33±0.12	1.49±0.22	2.14±0.07	1.95±0.12
	Control	5.47±0.15	1.43±0.29	2.17±0.08	2.14±0.03
PBC[b] (log CFU/g)	Coated	5.75±0.17	1.12±0.02	1.71±0.05*	1.56±0.03*
	Control	6.12±0.20	1.14±0.02	1.85±0.03*	1.92±0.05*
TVN[c] (mg/100gr)	Coated	5.60±1.40	10.73±0.81	5.60±1.40	16.40±4.54
	Control	5.57±2.00	13.53±2.14	8.63±4.76	19.67±1.30
Moisture (%)	Coated	75.41±0.21	69.03±10.51	46.64±1.38	57.02±12.31
	Control	75.16±0.52	67.54±7.54	49.62±7.49	55.24±10.45

a-Total microbial count, b-Psychrophilic bacteria count, c- Total volatile nitrogen
Replicates=3 (for all samples)
*shows significant difference (p<0.05) between treatments
Similar letters show significant differences in rows.

Chemical characteristics

TVN means of the coated and uncoated samples during 0, 1, 4 and 8 weeks of storage at -18°C are displayed in table (1). According to the results of Analysis of Variance, there was no significant difference in TVN between the coated and uncoated samples (Table 1).

Moisture content means of the coated and uncoated samples during 0, 1, 4 and 8 weeks of storage at -18°C are displayed in Table (1). According to the results of Analysis of Variance, there was no significant difference in moisture content between the coated and uncoated samples (Table 1).

DISCUSSION

Limited studies were found in the literature regarding the effect of edible coatings on frozen lamb muscle. Therefore, present results were compared to meats other than lamb muscle. In the current research, there was no statistically significant difference in total microbial count between the coated and control muscle samples; however, total microbial count of the coated samples was reduced in comparison with the controls. Effects of an edible calcium alginate coating, Flavor-Tex on lamb carcasses at 4°C were not significant [9]. Similar results were obtained by the application of the same coating for the retail beef pieces stored at 5°C [10]. Reduction in total microbial count of the coated samples may be due to that calcium alginate acts as a barrier against oxygen transfer and prevents growth of aerobic bacteria [11]. In another study, total microbial counts of buffalo meat patties coated with sodium alginate containing preservatives decreased when compared to the controls [12]. Total bacterial and staphylococcal counts (1.44-2.51 log CFU/g) of frozen gutted kilka coated with whey protein based edible film incorporated with sodium alginate decreased in comparison with the control samples (2.28-3.21 log CFU/g). Total microbial count reduced before frozen storage and more reduction was observed after freezing [17]. Comparing to sodium alginate coating incorporated with vitamin C or tea polyphenols, total microbial counts of sodium alginate coated and control samples increased more rapidly during 21 days of storage at 4°C and the differences were statistically significant. In other words, sodium alginate coatings containing vitamin C or tea polyphenols, efficiently prevented total microbial growth. Generally, all the treatments significantly inhibited bacterial growth in the storage period compared to the control samples [17]. According to the results of another research, total aerobic microbial counts of sodium alginate coated rainbow trout fillets were significantly lower than those of control samples [25]. In the present research, total microbial counts of the coated and control samples after 8 weeks of storage at -18°C did not exceed Iran's National Standard's acceptable limit of 5 log CFU/g [20]. This result shows that frozen muscle samples maintained their quality in this respect. Freezing which also reduces or inhibits growth of microorganisms, may be involved in decrease of total microbial count level.

In this study there is significant difference in psychrophilic bacterial counts between the coated and control samples on weeks 4 and 8 ($p<0.05$). In another investigation, psychrophilic microorganisms counts of the coated samples with sodium alginate containing preservatives decreased [12]. Total psychrophilic bacterial count of sodium alginate coated rainbow trout fillet samples at the end of 20 days of storage at 4°C was significantly lower than that of the control samples [25]. In the current research total microbial count and psychrophilic bacteria count in the coated and control samples significantly decreased from week 0 to week 1 ($p<0.05$). This reduction probably resulted from the possible damages of freezing to microorganisms such as thermal shock. A similar study confirmed our result [17]. Organic acids immobilized calcium alginate gel coating resulted in significantly greater reduction in viable count of *Listeria monocytogenes* attached to lean beef surfaces after 6 days compared with the acid treatments without alginate [26]. Calcium alginate edible film incorporated with garlic oil had significant inhibitory effects on *Staphylococcus aureus* and *Bacillus cereus* [27]. Alginate containing sodium lactate and sodium acetate significantly retarded growth of *listeria monocytogenes* in cold-smoked salmon slices and fillets [14]. Antimicrobial based alginate coatings efficiently enhanced quality and safety of ready-to-eat poultry products during the refrigerated storage [28]. TVN's acceptable limit of 16.5 mg/100gr for beef was determined by Pearson[29].TVN's level of higher than this limit indicates a sign of spoilage and reduction of organoleptic quality of meat [29]. In the present study, TVN means of the coated samples were lower than those of the controls after 1, 4 and 8 weeks storage; however, there was no significant difference in TVN between the coated and control muscles. Lower level of TVN in the coated samples may be due to the alginate coating effects such as slower growth of bacterial population or reduction of bacterial capacity for oxidative deamination of non-protein nitrogen compounds (or both) [30,31]. In another research, TVN levels of sodium alginate coated samples (15.63 mg/100g) were significantly lower than those of controls (34.06 mg/100g) ($p<0.05$) [25]. Reduction of TVN was observed in frozen sodium alginate coated dressed kilka [16]. TVN levels of gutted kilka samples coated with whey protein based edible film incorporated with sodium alginate also significantly decreased in comparison with the controls ($p<0.05$) [17]. Similar results were obtained in another study [11].

The present results showed no statistically significant difference in moisture content between the coated and control samples. In a previous study, the coated precooked pork chops with $CaCl_2$-gelled alginate-starch coatings stored at 4°C for 3, 6 or 9 days had not significant moisture loss [31]. Product shrink of the coated fresh beef steaks, pork chops and skinned chicken drumsticks by immersion (1s) in an aqueous solution of sodium alginate or sodium alginate and regular corn starch or sodium alginate and oxidized starch, followed by immersion in a 5 mol/L $CaCl_2$ solution (1-2s) was generally reduced by the coatings after storage at 1°C and 85-95% relative humidity for 1, 2, 4 and 7 days [32]. There was significant ($p<0.05$) reduction in overall moisture level of sodium alginate coated buffalo meat patties between days 0 and 7 and days 14 and 21 [12]. In a recent study moisture content of frozen Kilka coated with whey protein based edible film incorporated with sodium alginate increased significantly in comparison with the controls ($p<0.05$) [17]. Content of sodium alginate existing in the coated film had a significant effect on the moisture content of frozen kilka and an increase in sodium alginate concentration led to significant decrease in moisture level ($p<0.05$). Coating containing 1.25% sodium alginate was chosen as the most effective one and lipid based materials were recommended to be used in the compound of sodium alginate nutritional film to prevent moisture reduction of frozen kilka [16]. Treatment of lamb carcasses with calcium alginate coating, Flavor-Tex at 4^oC resulted in a significant decrease in 24-hr shrinkage loss than the controls [9]. The calcium alginate coating reduced shrinkage in the 40 evaluated beef steaks. The calcium alginate coating process resulted in the addition of approximately 15 gr to weight of the steaks. The coated steaks had significantly lower shrinkage values for 96 hr of storage than the uncoated steak [10].The mechanism by which the coating retarded moisture loss was explained by Morris [33].

CONCLUSION

In the present study psychrophilic bacteria counts were significantly different between the coated and uncoated muscles ($p<0.05$). Total microbial counts, TVN and moisture content were not significantly different between the coated and uncoated samples; however, total microbial count and TVN of the coated muscles were lower than those of uncoated muscles.

Regarding role of psychrophilic bacteria in meat spoilage, results of this research to some extent confirmed effectiveness of calcium alginate coating on the shelf life extension of frozen lamb muscle. Nevertheless, further investigations in this area are necessary.

ACKNOWLEDGEMENTS

This publication is part of the results of a research project (code 2122, 2006) supported by the National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

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