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Effect of beta glucan and carboxymethyl cellulose on lipid oxidation and fatty acid composition of pre-cooked shrimp nugget during storage☆

Mehrdad Haghshenas, Hedayat Hosseini*, Kooshan Nayebzadeh, Behnoosh Shabkoohi Kakesh, Maryam Mahmoudzadeh, Rozita Komeyli Fonood

Department of Food Sciences and Technology, National Nutrition and Food Technology Research Institute, Faculty of Nutrition and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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ABSTRACT

Oil extraction from the pre-cooked shrimp nugget with carboxymethyl cellulose and β-glucan was evaluated for peroxide value (PV), p-anisidine value, thiobarbituric acid (TBA) and fatty acid composition in frozen storage for a period of 4 months. After 4 months of frozen storage, Control and CMC shrimp nugget with the highest TBARS values had the greater lipid oxidation than samples containing β-glucan. However, no significant differences were found in BG and CMC + BG samples at 120 days of storage ($p > 0.05$). p-anisidine value of shrimp nuggets oil without β-glucan were significantly higher than those of shrimp nugget oil containing β-glucan and during storage ($p < 0.05$). The BG + CMC treatment showed the highest amount of polyunsaturated fatty acids after 120 days. Also, our data showed that there were positive correlations among the results of antioxidant capacities and total phenolic acids of the samples. In conclusion, this result revealed that β-glucan added to shrimp nugget can significantly retard the process of lipid peroxidation during storage.

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1. Introduction

Consumption of breaded and battered foods especially seafood, poultry, cheese, and vegetables has become very popular over the last few years (Antonova, Mallikarjunan, & Duncan, 2003; Lee, Joaquin, & Lee, 2007; Sanz, Salvador, & Fiszman, 2004). Shrimp is one of the most popular seafood products for many countries due to its unique flavor and texture. Dehghan Nasiri, Mohebbi, Tabatabaee Yazdi, and Haddad Khodaparast (2012) cited the United States National Marine Fisheries Services reports about increase in shrimp consumption per capita from an average of 1.0 kg per year in 1989 to of 1.8 kg in 2005. Iranian shrimp has a superior quality which makes shrimp industry an export-oriented business (Dehghan Nasiri et al., 2012). On the other hand increased prevalence of diabetes, cardiovascular diseases, cancer and obesity in the past few decades has raised public awareness related to diets rich in antioxidants and polyphenols (Daou & Zhang, 2012). Polyphenols have various biological functions, such as antioxidant, anti-inflammatory and anti-cancer activities that can protect the human body, which is constantly exposed to free radicals present externally, as well as produced internally. β-glucan of cereals is a soluble dietary fiber with potential health benefits including cholesterol lowering ability and slower glucose absorption (Volikakis, Biliaderis, Vamvakas, & Zerfiridis, 2004). Thondre, Ryan, and Henry stated that health benefits associated with β-glucan samples might depend on their polyphenol and antioxidant contents that vary with method of preparation and purity (Thondre, Ryan, & Henry, 2011). Many natural compounds, especially phenolic compounds, possess significant antioxidant properties such as metal chelation, scavenging of free radicals and inhibition of lipid peroxidation (Aktumsek, Zengin, Guler, Cakmak, & Duran, 2011). Also, consumer demand

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* Corresponding author. No.7, Hafezi St, Farahzadi Bulvard, P.O. Box: 19395-4741, Shahrake-Gharb, Tehran, Iran. Tel.: +98 2122376426; fax: +98 2122360660.
E-mail address: hedayat@sbmu.ac.ir (H. Hosseini).

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for high quality and long shelf life products and the increased awareness of environmental issues are some of the reasons that have promoted the growing interest in developing edible films from biodegradable materials. Cellulose is the most abundant renewable resource, and its derivatives have excellent film-forming properties. Cellulose derivative based coatings are very efficient barriers to oxygen and aroma compounds. Water soluble cellulose derivatives such as methyl cellulose (MC), hydroxypropyl methyl cellulose (HPMC) and carboxymethyl cellulose (CMC) are of interest to researchers since they are able to form a continuous matrix. CMC is a cellulose ether that exhibits thermal gelation, forming excellent coatings (Ghanbarzadeh & Almasi, 2011). Because they are highly hydrophilic they present only a limited barrier to moisture, mainly acting as sacrificing agents in the case of high-moisture gelatinous coatings. However, they are good oxygen barriers and can provide protection against lipid oxidation (Varela & Fiszman, 2011). For this reason, it is widely used in the pharmaceutical and food industries. The aim of the present study was to characterize the effect of beta glucan and carboxymethyl cellulose on fatty acid composition and lipid oxidation of shrimp nugget during storage.

2. Materials and methods

2.1. Preparation of batters and shrimp nuggets

Four different shrimp nuggets were prepared and manufactured according to the formulations shown in Table 1. A reference batter was prepared by mixing Egg powder (10.4 gr/100gr) and wheat flour (89.6 gr/100gr). In CMC formula 1 gr/100gr Carboxymethyl cellulose (Sunrose, Japan) was added, replacing the same amount of batter wheat flour. The water/dry mix proportion was always kept at 2:1. The temperature of the water before mixing was 25 °C. The Metapenaeus affinis shrimps used were obtained from a local producer (Mobarakian, Iran). The shrimps were held under hygienic condition at −18 °C for 2 days before processing. The BG formula was consisted of 3 gr/100 gr β-glucan in center of nuggets was used instead of 3 gr/100 gr bread crumb. β-glucan used was of 34 gr/100 gr purity and obtained from promOat (promOat, Swedish). The cleaned shrimps were ground by grinder and according to the four formulations shown in Table 1. Additives were added and mixed to make raw nugget paste. The shrimp former was filled with paste and shaped nuggets. After forming, predusting, battering and breading was done respectively. Then raw nuggets were steam cooked for 35 min to achieve an internal temperature of about 85 °C to make pre-cooked nuggets. After these stages shrimp nuggets were frozen by IQF (CFS Koppens Spiral Freezer, Model: SVR 600) packaged and stored at −18 °C (Venugopal, 2006).

Table 1
Experimental design and formulations.

Formulation (%)	C	CMC	BG	CMC + BG
Shrimp	70	70	70	70
Bread crumb	10.1	10.1	7.1	7.1
Sunflower oil	4.5	4.5	4.5	4.5
Carboxymethyl cellulose	–	0.03	–	0.03
Β-glucan	–	–	3	3
Onion	1.5	1.5	1.5	1.5
Skim milk	1	1	1	1
Salt	1	1	1	1
Sodium caseinate	0.5	0.5	0.5	0.5
Soy isolate	0.5	0.5	0.5	0.5
Hot pepper flavor	1	1	1	1
Black Pepper flavor	0.2	0.2	0.2	0.2
Nutmeg flavor	0.1	0.1	0.1	0.1
Batter wheat flour	2.6	2.57	2.6	2.57
Egg powder	0.3	0.3	0.3	0.3
Water	5.8	5.8	5.8	5.8

Formulations: C, control; CMC, Carboxymethyl cellulose 1% of batter; BG, 3% β-glucan in center of nuggets; CMC + BG, Carboxymethyl cellulose 1% of batter and 3% β-glucan in center of nuggets.

2.2. Extraction of oil

Frozen shrimp nuggets were defrosted at ambient temperature and then homogenized using a Waring blender for about 1 min 50 g of each grinded sample was put into a 500 ml beaker and 300 ml of n-hexane (ratio product: solvent 1:6) added. Extractions were carried out by stirring at 50 °C for 3 h. After extraction, the suspensions were filtered (Whatman paper No. 1) and the solvent evaporated by a Rotavapor R114 (Bü chi, Switzerland) (Severini, De Pilli, & Baiano, 2003).

2.3. Determination of peroxide value (PV)

The peroxide value was determined and expressed as meq O_2/kg oil, according to (AOCS, 1998) method Cd 8b-90 (AOCS, 1998).

2.4. Thiobarbituric acid (TBA) measurement

The samples were analyzed in duplicate for 2-TBARS value direct method using the spectrophotometric technique, as described by AOCS method Cd 19-90 (AOCS, 1998).

2.5. Determination of p-Anisidine value (An V)

p-Anisidine value of oil was analyzed according to the method of AOCS Recommended Practice Ti la-64. The weight of extracted oil (100 mg) was dissolved in 25 ml of isooctane and measured at 350 nm using UV–visible spectrophotometer (Lamda EZ201 UV/vis spectrophotometer; Perkin Elmer, USA). This solution (2.5 ml) was mixed with 0.5 ml of 0.5% (w/v) *p*-anisidine in acetic acid for 10 min. The absorbance was read at 350 nm. The *p*-anisidine value was calculated by this formula: *p*-anisidine value = 25 × [(1.2 × As − Ab)/W]; where As = the absorbance before adding *p*-anisidine, Ab = the absorbance at 350 nm after adding *p*-anisidine and W = weight of sample (g) (AOCS, 1998).

2.6. Fatty acid composition

The fatty acid composition was determined by GC after derivatisation to fatty acid methyl esters (FAME) with 2 N KOH in methanol, according to IUPAC Standard Methods 2.301 and 2.302. An Agilent 6890 GC system (Agilent Technologies, Santa Clara, CA) equipped with a split/splitless injector, an Innowax capillary column (30 m length, 0.25 mm i.d., 0.20 lm film thickness) and a flame ionisation detector (FID) was used. Hydrogen was used as carrier gas. The detector and injector temperatures were 250 °C. The initial oven temperature was 180 °C and a temperature gradient from 180 to 220 °C at 3 °C min^{-1} was applied. Injections were performed using a split ratio of 1:50 (IUPAC, 1992).

2.7. Determination of phenolic acids

Phenolic acids were analyzed according to validated methods with slight modifications in HPLC elution conditions. They were analyzed in an HPLC chromatograph system (Perkin Elmer, Flexar, USA) equipped with Diode Array Detector (DAD) and a reversed-phase C18 column (Perkin Elmer ODS-2, 5 lm, 250 mm _4.6 mm) (Mattila, Pihlava, & Hellström, 2005; Xu et al., 2009).

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