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Effect of ionizing radiation on the protein and lipid quality characteristics of mutton kheema treated with rice bran oil and sunflower oil

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HIGHLIGHTS

- RBO as an effective cooking medium and an antioxidant in development of meat products.
- Negative impact on quality of protein and fat with respect to dosage increase.
- Role of non-heme iron as a catalyst in lipid oxidation during irradiation.
- Positive effects of RBO in inhibiting lipid and protein oxidation during irradiation.
- RBO and FSO treatment yielded a stable designer meat product as per WHO recommendations.

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ABSTRACT

Effect of rice bran oil (RBO) and irradiation (0, 1, 2 and 3 kGy) on lipid and protein quality of ready-to-eat mutton kheema were established during refrigerated storage (4 ± 1 °C). Total carbonyls, thiobarbituric acid reactive substance (TBARS), non-heme iron and total volatiles in irradiated RBO samples were significantly lower ($p < 0.05$) from the corresponding sunflower oil (SFO) treated samples initially and during storage. Product with RBO and Flaxseed oil (FSO) at the optimized level yielded a designer meat product having an SFA:MUFA:PUFA and n-6/n-3 ratio of 1:1.3:1.3 and 3.6:1 respectively. Degradation in PUFA levels in SFO samples were significantly higher ($p < 0.05$) and an increase of 31% in metmyoglobin after 50 days was noticed in comparison with RBO samples. Non-linear correlation analysis of chemical markers established polynomial fit equations. 2 kGy radiation processing with RBO yielded a product having 50 days of shelf stability in terms of its chemical characteristics.

1. Introduction

Meat irradiation is considered to be a safe and effective method to lengthen the shelf life of fresh meat and meat products (Kanatt et al., 2006). Food and Drug Administration (FDA) approved the poultry and red meat irradiation for control of food borne pathogens and to extend product shelf life. Irradiation is a promising preservation technology; however, its application in meat and its products lead to physico-chemical and biochemical changes, affecting nutritional value and sensory quality (Grolichova et al., 2004). Radiation processing of muscle foods generates free radicals and accelerates lipid and protein oxidation resulting to undesirable changes (Alfaia et al., 2007). The most important contributor for lipid peroxidation is considered to be polyunsaturated fatty acids (Du et al., 2000). The formation of carbonyl compounds which releases characteristic off-odor volatiles during irradiation process is one of the important modifications in meat products (Estévez, 2011).

Natural and synthetic antioxidants are commonly employed to control the oxidative reactions during processing of meat and its products. Antioxidants are considered to be compounds that are able to retard, delay or prevent oxidation processes. Incorporation of antioxidants helped in protecting from lipid peroxidation in several irradiated meat and meat products. Rosemary and oregano extracts have antioxidant capacity on irradiated frozen beef burgers (Trindade et al., 2010). Formanek et al. (2003) studied the combined effects of irradiation and the use of natural antioxidants on the shelf-life stability of minced beef. Plums have established antioxidant properties in products such as irradiated turkey, precooked pork sausage, and roast beef (Nunez de Gonzalez et al., 2008). The efficacy of mint leaves (Kanatt et al., 2007) and chitosan

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(Kanatt et al., 2006) as natural antioxidants was established in radiation-processed lamb meat. Studies on the positive effects of lactic acid (Jayathilakan et al., 2009) and tocopherol in combination with sesamol (Nam and Ahn, 2003) were reported in irradiated poultry and pork samples respectively.

Rice bran oil (RBO) is an important cooking oil, which is widely utilized. RBO is having a balanced fatty acid profile in terms of saturated, monounsaturated, and polyunsaturated fatty acids and moreover rich in functional components like tocopherols, tocotrienols and gamma oryzanol which are known to have health promoting properties as simply as good antioxidants (Soheir, 2010). The positive effect of γ-oryzanol in controlling the oxidative deterioration of beef patties were reported by Kim et al. (2003). Jalarama Reddy et al. (2014) studied the feasibility of employing RBO as a cooking medium for the development of poultry products with superior shelf stability.

Development of meat products with added functional attributes and to enhancing the shelf stability is a promising technological necessity to meet the demands of consumers. As such literature is scanty on the effect of RBO in developing meat products using emerging non-thermal preservation techniques like irradiation. Therefore, studies have been taken up to establish the effect of radiation processing with RBO on the stability of lipid and protein in RTE mutton kheema by evaluating different chemical markers.

2. Materials and methods

2.1. Meat samples

Fresh mutton was purchased from the local market, washed thoroughly under running water, deboned and cut into small pieces (1.5 cm × 1 cm) and subjected for marination with lemon juice, salt and spices. After marination for 1 h it was subjected for partial cooking and mincing using a Hobart Mincer (Model 4812-CE).

2.2. Spices

Various green spices, e.g., onion, garlic, ginger, green chillies, turmeric, pepper, cloves, cinnamon and cumin were purchased from the local market.

2.3. Reagents and chemicals

All the reagents and chemicals used in the study were of Analar grade and procured from M/s BDH Company. The standard fatty acid methyl esters used in the estimation of fatty acids by Gas chromatography and the BF3-CH_3OH used in the esterification were obtained from Sigma Chemicals Corporation, USA.

2.4. Edible oils in the product preparation

RBO used in the present investigation was received from M/s Habib Agro Industries, Mandya, Karnataka, India and flaxseed oil was obtained from M/s SSS Industries, Bangalore, India. Sunflower oil (SFO) was purchased from local market.

2.5. Preparation of the product

The wet masala paste was made by using onion, garlic, ginger, green chillies and turmeric powder. Acidity and salt were adjusted. Masala was divided into two portions: one portion fried in RBO–FSO and the other in SFO. Minced mutton was added and mixed with these two combinations.

The samples (~50 g each) were packed separately in PFP [paper/foil/polyethylene packages (45 GSM paper/20 (Al foil/37.5 (low density LDPE)))] for radiation processing of the product at different dosage levels.

2.6. Sample code

In this study three dosage levels of radiation have been applied. 1, 2 and 3 kGy along with non-irradiated sample (0 kGy). Each category four samples, i.e., A–D (SFO treated) and E–H (RBO treated). Thus, there are 8 samples for analysis.

A – SFO 0 kGy; B – SFO 1 kGy; C – SFO 2 kGy; D – SFO 3 kGy;E – RBO 0 kGy; F – RBO 1 kGy; G – RBO 2 kGy; H – RBO 3 kGy.

2.7. Irradiation of RTE mutton kheema samples

The samples were subjected to γ-irradiation using Cobalt 60 as source with the help of Gamma irradiation chamber-5000 with an effective dosage rate of 5.57 kGy/h having chamber temperature of 35 °C. The samples were exposed to 1, 2 and 3 kGy dosage levels at a time period of 10, 21 and 32 min respectively. The absorbed irradiation dose was measured by using a ceric-cerous standard dosimeter that was attached to the surface at the top and bottom of each packaged samples. The dose uniformity in the irradiated samples expressed as D_{max}/D_{min} was found to be 1.01. The samples were stored at refrigerated temperature for the periodic evaluation of quality characteristics with regards to lipid and protein of the product.

2.8. Proximate analysis

Proximate composition of the sample was determined as per AOAC (2000) methods for moisture, protein, fat, carbohydrate (by difference method) and total ash.

2.9. Analysis of chemical markers

2.9.1. Total carbonyls

Total carbonyl expressed in terms of mg of n-hexanal/100 g fat was monitored by the method of Benca and Mitchela (1954). Five grams of the sample were extracted in 50 ml of carbonyl free benzene and 5 ml of the sample filtrate were treated with 3 ml of 3–4% trichloracetic acid in benzene and 5 ml of 0.05% DNPH solution in benzene and incubated at 60 °C for 30 min. After cooling, 4% alcoholic KOH was added and volume made up to 50 ml with ethanol. After 10 min, absorbance was read at 480 nm. A standard curve was drawn using hexanal (10–50 mg) in 5 ml benzene instead of sample extract. Total carbonyls were calculated with the help of a standard curve and expressed as mg of hexanal/100 g of fat.

2.9.2. Total volatile content

Total volatile content of the samples was estimated as per Weurman (1969). 100 g of samples were taken in a simultaneous steam distillation, evaporation flask and connected to a distillation head. 100 ml of dichloromethane was taken in a 500 ml round bottom flask and connected to receiving end of the distillation flask. The distillation was carried out for 2 h and the solvent containing flavor compounds was dried over anhydrous sodium sulfate, evaporated and weighed. The total volatile content was estimated as follows:

$$\text{Total volatile content (mg/kg)} = \frac{1000 \times \text{weight of the volatile}}{\text{weight of sample}}$$