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Effect of Gamma Irradiation Technology on the Microbial Quality and Sensory Attributes of Fresh Meat in Pondok Labu Traditional Market, South Jakarta

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Abstract: Gamma irradiation can be used as one of the most efficient methods to reduce microorganisms in food. The irradiation of food is used for a number of purposes, including microbiological control, insect control and inhibitions of sprouting and delay of senescence of living food. The aim of the present study was to analyze the effect of gamma irradiation technology on their microbial quality (total plate count, coliform and fungal count) and sensory attributes of fresh meat. Twenty fresh meat samples were collected from Pondok labu traditional market in South Jakarta. The fresh meat samples were treated with 0, 1, 2, 3 kGy gamma irradiation dose. Exposure to gamma irradiation in Co^{60} driven irradiating facility was performed at the Center for the Application of Isotopes and Radiation Technology, National Nuclear Energy Agency of Indonesia (BATAN) in Jakarta. Irradiation had highly significant effects ($p<0.01$) on reduction of microbial population. Microbial analysis indicated that gamma irradiation was effective in reducing those microorganisms and the optimal dose was achieved at 3 kGy. The results have shown not only the need for sanitary conditions improvements in slaughter and processing of fresh meat but also the irradiation effectiveness to eliminate total bacteria, coliform and fungi count. This study showed that irradiation had no significant effects ($p>0.05$) on the sensory attributes of fresh meat.

Key words: Gamma irradiation, fresh meat, microbial quality

INTRODUCTION

The issue of food security is a complex one in both developed and developing countries, where proteins source from animals such as meat and meat products, are generally regarded as high risk and unwholesome commodities with respect to pathogen contents, availability of natural toxins and other possible contaminants and also the use of adulterants (Yousuf *et al*., 2008). Food borne infections and illnesses have become a major international health problem with consequent reduction in economic growth. It is also identified as a major cause of illness and death worldwide (Agyei and Maalekuu, 2014). Recognizing this, International food management agencies, especially the World Health Organization (WHO), the Food and Agriculture Organization and the International Hazard Analysis Critical Control Point (HACCP) Alliance have already provided guidelines to member countries about safe handling procedures such as HACCP and Good Manufacturing Practices (GMPs). According to Clarence *et al*. (2009), food borne diseases are diseases resulting from ingestion of bacteria, toxins and cells produced by microorganisms present in food. The intensity of the signs and symptoms may vary with the amount of contaminated food ingested and susceptibility of the individuals to the toxin.

Meat is a rich nutrient matrix that provides suitable media for growth and proliferation of common spoilage and pathogenic microorganisms. Contaminated raw meat is one of the main sources of food-borne illness (Bhandare *et al*., 2007). It has been known that most food contaminations are caused by food-borne pathogens such as bacteria, fungi, mold and others. The possible sources of these bacteria are likely to come from the skin of the animal from which the meat was obtained. Other potential sources of microbial contaminations are the equipment used for each operation that is performed until the final product is eaten, the clothing and hands of personnel and the physical facilities themselves are all implicated. According to the National Agency of Drugs and Foods Controls of Indonesia (BPOM, 2014), a number of food (meat and meat products) have been reported to high incidence of bacteria. A comprehensive understanding and study of the microbial ecology of meat in our markets and the factors that lead to microbial contamination and their multiplication is needed for effective management and maintenance of high quality and safe food.

Food preservation methods have been improving together with sciences advances. Among the alternative technologies that are being adopted for food treatment worldwide, irradiation should be highlighted. Researches show that this conservation method could apply to both industry and consumers interests (Silva, 2008). The irradiation of food products is a

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physical treatment involving direct exposure to electron or electromagnetic rays, for their long time preservation and improvement of quality and safety (Prakash *et al*., 2014; Mahindru, 2005).

Data about the gamma radiation effects on microorganisms found in fresh meat are still limited. This study aimed at analyzing the effect of gamma irradiation technology on their microbial quality (total plate count, coliform and fungal count) and sensory attributes of fresh meat. The fresh meat samples were treated with 0, 1, 2, 3 kGy gamma irradiation dose. Its findings might help the control and prevention of food-borne diseases.

MATERIALS AND METHODS

Sample preparation and irradiation: Twenty fresh meat samples (250 g each) were obtained from a Pondok Labu Traditional Market, South Jakarta. The samples were collected and transferred immediately to the laboratory for further analysis and identified according to the treatment to be applied as follows: control (non-irradiated), irradiated with 1, 2 and 3 kilo-gray (kGy). All samples were brought to laboratory and were packed in polythene bags and all the four sides were electrically sealed and then repacked into another cover and that too was sealed. The samples were kept in the refrigerator until irradiating. Samples were ice packed and air lifted to multipurpose panoramic batch irradiator (IRPASENA) at the Center for the Application of Isotopes and Radiation Technology, National Nuclear Energy Agency of Indonesia (BATAN). The samples packets were removed from the ice and the surface of the covers were wiped using tissue paper and irradiated using a Gamma radiation in a Co^{60} source of radiation a dose with 1, 2 and 3 kGy. The irradiated samples were packed in cardboard box and air lifted to the microbiological laboratory for doing microbial and sensory analysis.

Microbial analysis

Total plate count (TPC): Bacterial counts were analyzed by spread plate method using Plate Count Agar (PCA, Oxoid CM 0325) (Prakash *et al*., 2014; ISO, 2003a). Twenty five g of fresh meat sample was macerate with 225 ml of saline water using mortar and pestle. It is serially diluted and 1 ml of the supernatant was mixed with 9 ml of saline water (10^{-2}) and it was serially diluted as 10^{-3} and 10^{-4}. After serial dilutions inoculate 1 ml of each of the dilutions was poured on agar plates in duplicates. Using a sterile bent glass rod spread the inoculums uniformly on the surface of the plates. Incubate the plates at 37°C for 48 h. After incubation all white spots or spread were counted and recorded as total viable counts using the colony counter. The counts for each plate were expressed as colony forming unit of the suspension (CFU/g).

Total coliform: For the numeration of total coliform was carried out by employing of standard methods (ISO, 2003b) using Crystal Violet Neutral red bile lactose (VRBL) agar (Oxoid CM 0107), 1 ml of appropriate dilutions on poured-plated; plates were incubated at 37°C for 48 h. The counts for each plate were expressed as colony forming unit of the suspension (CFU/g).

Total fungal count (TFC): Total Fungal Count was assessed using Potato Dextrose Agar (PDA, Merck-Germany) (Prakash *et al*., 2014; Surendran *et al*., 2006). Twenty five g of the sample was blended with 225 ml of 0.1% peptone water in a blender for 30 sec. One milliliter of the appropriate dilutions of the sample was spread on the surface of the medium. Incubate the plates at room temperature (28±1°C) for 3-5 days and examine the plates for fungal colonies and record the number of colonies per gram of the samples. The counts for each plate were expressed as colony forming unit of the suspension (CFU/g).

Sensory analysis: In this study, a 4-member trained sensory attribute panel evaluated fresh meat. Two training sessions were performed for the panelists before their participation in the formal panel. Fresh meat samples were evaluated for external appearance, color, texture and overall quality. The samples were transferred to glass containers with plastic covers to maintain the external appearance of the meat. For evaluation of texture, each panelist put on a glove and touched the samples. Acceptability of fresh meat was evaluated using a 9-point hedonic scale, where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely (Peryam and Pilgrim, 1957). Scores from 6 to 9 were considered acceptable (Paul *et al*., 1990).

Statistical analysis: Statistical tests included Variance analysis (ANOVA) with a 5% significance level and mean comparisons according to Tukey's test (SAS, 1999).

RESULTS AND DISCUSSION

Total plate count (TPC): The results for the total plate count, total coliforms and total fungal count analyses of fresh meat performed in the control (non-irradiated) and in samples treated with 1, 2 and 3 kGy are shown in Table 1, 2 and 3. Total count of bacteria decrease with increase of irradiation dose. Mean of bacterial total count, Coliform count and fungi count were 4.6486, 4.7481 and 4.4805 log CFU/g at control samples (0 kGy), respectively. According ANOVA analysis, the number of total plate count, Coliform and fungal count decrease with increase of irradiation, therefore irradiation highly significant ($p<0.01$) reduce them. In this study also non-irradiated fresh meat had high microbial

Table 1: Total plate count (TPC) log CFU/g in non-irradiated and irradiated fresh meat

	Irradiation dose (kGy)			
Samples	0 (NI)	1	2	3
1	4.6866	3.3945	2.7419	2.3304
2	4.5977	3.4533	2.9117	2.1139
3	4.7024	3.4770	2.5658	2.3802
4	4.6628	3.4149	2.4594	2.3692
5	4.5933	3.4654	2.4410	2.2742
Average	4.6486±0.05^{B}	3.4410±0.04^{A}	2.6239±0.20^{A}	2.2936±0.11^{A}

NI: Non irradiated, mean with the different letter are highly significant difference ($p<0.01$)

Table 2: Total coliform count log CFU/g in non-irradiated and irradiated fresh meat

	Irradiation dose (kGy)			
Samples	0 (NI)	1	2	3
1	4.8008	3.3181	2.4533	2.0645
2	4.6628	3.5705	2.4014	0
3	4.7513	3.1931	2.0645	0
4	4.7388	3.4997	2.1584	0
5	4.7868	3.5051	2.2355	0
Average	4.7481±0.05^{B}	3.4173±0.16^{A}	2.2626±0.16^{A}	0.4129±0.92^{A}

NI: Non irradiated, mean with the different letter are highly significant difference ($p<0.01$)

Table 3: Total fungal count log CFU/g in non-irradiated and irradiated fresh meat

	Irradiation dose (kGy)			
Samples	0 (NI)	1	2	3
1	4.6149	3.3729	2.6107	2.5705
2	4.3181	3.5752	2.7388	2.0934
3	4.4997	3.4216	2.3502	2.0170
4	4.4281	3.5465	2.4654	2.4409
5	4.5416	3.4216	2.3096	2.2833
Average	4.4805±0.11^{B}	3.4676±0.09^{A}	2.4949±0.18^{A}	2.2810±0.23^{A}

NI: Non irradiated, mean with the different letter are highly significant difference ($p<0.01$)

Table 4: Value of sensory attributes of non-irradiated and irradiated fresh meat

Irradiation dose (kGy)	External appearance	Colour	Texture	Overall acceptability
0 (NI)	9	8	8	9
1	8	9	8	9
2	9	9	8	9
3	9	8	9	8

NI: Non irradiated

population and gamma irradiation caused a reduction of total plate count in fresh meat samples.

The higher values could be as a result of contamination from the slaughtering area and equipment used. The slaughter of meat animals under unhygienic conditions, the use of contaminated water, use of unsterilized equipment such as knifes, rusted hooks, poor and unhygienic condition of abattoir located followed by production and processing of meat without adhering to good manufacturing practices can result to the increased level of total bacterial count in the fresh meat (Permentan, 2010). Also, from the studies, it can be seen that wale recorded the highest level of total plate count and this may be due to the way it is prepared. The meat during its preparation remains in the ground for a long time which creates an avenue for microbial pathogens to proliferate on it. From the results, it is evident that fresh meat from abattoir located recorded high total bacterial count.

The results of total plate count showed that the microbial loads of the irradiated samples were lower than control and this finding confirms the reduction of microbial count after irradiation of the fresh meat samples. Food spoilage microorganisms are generally susceptible to irradiation; 90% reduction of most vegetative cells can be accomplished with 1-1.5 kGy (Brewer, 2009). Ozkan *et al*. (2006) reported reduced microbial count after irradiation of refrigerated sea bream (*Sparus aurata*). Moini *et al*. (2009) reported that irradiation at 1, 3 and 5 kGy doses had a significant reduction effect on the total viable count in rainbow trout fillets. Noomhorm *et al*. (2000) reported reductions of microbes in the irradiated meat and fishery products. Javanmard *et al*. (2006) reported that irradiation has a significant reduction effect on the microbial load in chicken meat. Reduction of total bacterial and mould counts of fresh Chinese pomfret, *Pampus chinensis* was observed after gamma radiation (Ahmed *et al*., 2009). Mendes *et al*. (2005) reported that mesophilic bacteria count of irradiated shrimp, crab and fish were lower than those of non-irradiated samples during the storage at 4°C.

Coliform: The level of total Coliform was higher in control samples (0 kGy) than irradiated samples. With an increase in irradiation, the number of coliforms decreased. Therefore irradiation significantly reduced

them. The presence of coliforms is an indication of contamination by humans, birds or contaminated water used in washing both at the processing site and at the retail level (Talaro and Talaro, 2006). The result from this study is in line with the study of Jeffery *et al*. (2003) who reported that the workers hands and the equipment were the sources of meat contamination. The presence of high faecal coliforms in food depicts poor hygienic practices of handling of the meats during slaughtering and processing or due to possible contamination from the skin, mouth or nose of the handlers which might be introduced directly into the meat (Schroeder *et al*., 2005). Mantilla *et al*. (2010) also tested the effect of irradiation with doses of 3 kGy and a modified atmosphere (80% CO_2/20% N2) on the growth of coliforms bacteria in chicken meat. It was observed that total coliforms only developed in samples packed in air and in non-irradiated and non-modified atmosphere.

Total fungal count (TFC): In the present study total fungal count (yeast and molds) were decreasing in irradiated samples. The growth of filamentous fungi in food and food products results in waste and is costly as well as sometimes hazardous. Badr (2004) reported that irradiation of rabbit meat significantly reduced the counts of yeasts and molds by 84 and 94%, respectively. Ahmed *et al*. (2009) also reported that 4 kGy was needed to control fungal growth of sun dried fish. It has been stated that yeasts and molds are sensitive to the irradiation process because of their large genomic structure (Fallah *et al*., 2010). During radiation, DNA molecules undergo swelling and break alongside the chain, preventing them from functioning normally. As a result, the parasites and microorganisms that have been affected are no longer capable of reproducing themselves and they die (Lacroix and Ouattara, 2000).

Sensory analysis: The sensory assessment of irradiated and non-irradiated samples was investigated respect of sensory variables such as external appearance, color, texture and overall quality (Table 4). Average score for non-irradiated sample was 8-9 are same with irradiated sample it was 8-9. This was the highest score for organoleptic property. Both irradiated and non irradiated samples were in acceptable condition. Irradiation process was not significant effect ($p>0.05$) for sensory attributes of fresh meat. Because, in this study was not conducted samples storage. Therefore food irradiation provides safety and extends the shelf life of fresh meat because of its high effectiveness in inactivating pathogenic and spoilage microorganisms without deteriorating product quality (Ozden and Erkan, 2010).

Conclusion: According to all obtained data from microbial analysis, low-dose gamma irradiation (especially 3 kGy) can be applied for microbial control and the safety of fresh meat. The exposure of fresh meat to unhygienic practices from the point of production to traditional market level increases the level of microbial contamination in the produce. Gamma irradiation at 3 kGy was more effective than irradiation at 1 and 2 kGy in eliminating microorganisms of fresh meat. In addition, the current study showed the effect of irradiation methods for fresh meat preservation without compromising the nutritional or sensory quality.

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