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MICROBIOLOGICAL QUALITY AND ACCEPTANCE OF IRRADIATED MEAT PRODUCTS DURING STORAGE

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Abstract:

The demand for ready-to-eat meals is growing due to their convenience such as easy to serve and eat directly; and suitable for busy consumers with families, working people, school children and campers. Among food items, meat products are very popular. Sausages and burgers need to be cooked after been thawed from the frozen state before consumption. It would be very convenient if these products are easy to serve and can be eaten directly without any heating or cooked and displayed at room temperature on the shelves of retailers without frozen product facilities. Fresh chicken sausages and burgers were obtained from local meat product outlets and cooked thoroughly in oven (160oC) for 10 minutes and cooled. Samples were vacuumed packed individually in plastic-polyethylene pouches and irradiated at doses of 3 kGy, 5 kGy and 10 kGy, using60Co gamma irradiation at MINTec-Sinagama. Until irradiation was over, non-irradiated samples (control) were kept in refrigerator. The irradiated and non-irradiated samples were displayed at room temperature and tested after storage periods of 1 month. Microbiological analysis was carried out to determine status of bacteria (Total Plate Count) and fungi counts (cfu/g). Colour changes of the products were recorded using Colorimeter (Minolta) for lightness (L), redness (a) and yellowness (b) values. Acceptability of the irradiated products were determined through sensory evaluation by using 30 members (male and female) of untrained panellists.Pre-cooked chicken meat products samples irradiated with doses of 3 and 5 kGy were most preferred for most of the attributes. Irradiation with dose 5 kGy was suitable for pre-cooked chicken sausages and burgers for prolonged their shelf-life in room temperature for one month storage. These results demonstrated the ability of gamma irradiation for the decontamination of pre-cooked meat products and reliable process for food storage in commercial industry.

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Keyword:

Gamma, Irradiation, Meat products, Microbial, Storage

Introduction

The demand for ready-to-eat meals is growing due to their convenience such as easy to serve and directly eaten; and suitable for busy consumers with families, working people, school children and campers. Among food items, meat products are very popular. Sausages and burgers need to be cooked after been thawed from the frozen state before consumption. It would be very convenient if these products can be eaten directly without any heating or cooking procedure and displayed in the chilled temperature on the shelves of the retailers without frozen facilities. Processes such as heating, refrigeration, and freezing, as well as preservatives and fumigants used in food processing and storage are associated with many problems, such as effectiveness, cost, soundness, and environmental pollution (Amit et al., 2017). Irradiation technology was developed to meet the need of new food processing and storage technologies. In the food industry, irradiation technology is implemented using radioactive isotopes or mechanically generated ionization energy (Ham et al., 2017). It is a technology-intensive field that can be effectively utilized in the sanitization of processed products, safe storage and distribution, and for the improvement of manufacturing processes (Kim et al., 2020).

Irradiation technology is known to be the most efficient way to eliminate pathogenic and spoilage microorganisms without deteriorating the nutritional and organoleptic qualities of food during storage (Kim et al., 2010). Irradiation can be continuously applied without being affected by the temperature, humidity, or pressure of the food sterilization process (Hwang et al., 2021). It is also possible to increase the energy efficiency and sterilize contaminating microorganisms in packaged foods (Lee et al., 2024). Irradiation can prolong the shelf life of food when microbial spoilage is a limiting factor (Hwang et al., 2015). The 1980 FAO/IAEA/WHO joint expert committee on the wholesomeness of irradiated foods (JECFI) concluded that all foods irradiated at doses up to 10 kGy did not pose toxicological hazards or nutritional or microbiological problems.

Vural et al. (2006) informed that the low-dose gamma irradiation applications have increased the hygienic quality of raw meatballs and possible public health risks can be prevented. However, due to these demands, pre-cooked chicken sausages and burgers were formulated, packed in cooked condition instead of raw and frozen state and irradiated for decontamination and prolonged their shelf-life under refrigeration or room temperature. Gamma irradiation technology has positive effects for destroying the pathogen microorganisms and by improving the safety and shelf stability of food products without compromising the nutritional or sensory quality and its use is gradually increasing worldwide (Ahn & Nam 2004). While irradiation is an effective method to reduce microbial contamination, its impact on the texture, color, flavor, and overall quality of meat products over time is not fully understood. Additionally, improper storage conditions may lead to microbial growth or undesirable chemical changes, compromising product quality. Therefore, it is essential to evaluate how irradiation and storage conditions interact to maintain both the safety and quality of meat products, ensuring they meet regulatory standards and consumer expectations. This study was carried out to determine suitable dose to reduce microbiological count and render product free from pathogenic bacteria and assess the acceptability of irradiated pre-cooked chicken meat products.

Materials and Methods

Preparation And Irradiation of Pre-Cooked Chicken Meat Products Samples

Fresh chicken sausages and burgers were obtained from local meat product outlets and kept frozen at –5ºC. The sausages and burgers were cooked thoroughly in oven (160ºC) for 10 minutes, cooled and packed individually in packaging material (plastic-polyethylene) and vacuum sealed. For sensory evaluation, samples were packed separately. These packaged samples were irradiated in MINTec-SINAGAMA, Bangi, Malaysia with ^{60}Co gamma rays with doses of 3, 5 and 10 kGy. All samples were stored at room temperature for one month.

Microbiological And Colour Analysis

Samples (25g) in duplicates from the irradiated and their corresponding non-irradiated control batches were aseptically homogenized for 1 min with 225 ml sterile saline in a Stomacher (Seward Medical, UK). Appropriate serial dilutions of the homogenate were carried out. Total plate count by pour plate method, was determined using Plate Count Agar incubated at 30ºC for 48 hours and Potato Dextrose Agar for molds (incubated at 30ºC for 5 days). The results were expressed as colony forming units per gram. Colour changes of the products were recorded using Colorimeter (Minolta) for lightness (L), redness (a) and yellowness (b) values.

Sensory Evaluation

Acceptability of the irradiated pre-cooked chicken sausages and burgers was determined through sensory evaluation using 30 members (male and female) of untrained panelists comprising staff of Malaysian Nuclear Agency. A 5-points hedonic rating scale was used with number 5 as the most acceptable and number 1 as the most unacceptable. The attributes evaluated were color, smell, texture, taste, saltiness dryness, chewiness and overall acceptance. Statistical analysis using ANOVA test (SAS Institute, 1991) and comparisons were made by Duncan's multiple range tests.

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Results and Discussion

The irradiated chicken products with doses of 5 and 10 kGy were free from microbial counts (Table 1 and 3) and fungi counts (Table 2 and 4) after irradiation and one month storage at room temperature. Application of gamma irradiation up to a dose level of 10 kGy can be used to reduce the numbers of food spoilage microorganisms as well as food-borne pathogens in food products (Abu-Tarboush et.al.1996).

There is no significant different for the L (lightness) and b (yellowness) values of pre-cooked meat products after irradiated with all doses. The redness (a) values decreased in pre-cooked chicken sausages irradiated with dose 5 and 10 kGy (Figure 1). The pre-cooked chicken sausages irradiated at 3 kGy were more accepted in sensory evaluation for all the attributes after storage one month at room temperature while pre-cooked chicken burgers irradiated at 5 kGy were more accepted (Figure 3 and 4). The highly penetrative ionising energy has the ability to inactivate spoilage and disease-causing microorganisms without causing harmful changes to the products. The ionising energy passes completely through the products and their packaging. Thus, the products can be irradiated in their final packaging ready for the end-user. This process is a cold treatment and suitable to retain the acceptability of the products. Other food preservation methods such as chemical and heat treatment can kill microorganisms including pathogens. However, chemical leaves residues and heating treatment can change the texture, colour and flavour of the products (MINTec-SINAGAMA)

Table 1: The Number of Bacterial Colonies in Irradiated Pre-Cooked Chicken Sausages with Different Doses in One Month Storage at Room Temperature.

Irradiation Doses	**Microbial Count (CFU/g)**	
	0 month	**1 month**
0 kGy (Control)	0	0
3 kGy	0	0
5 kGy	0	0
10 kGy	0	0

Table 2: The Number of Fungal Colonies in Irradiated Pre-Cooked Chicken Sausages with Different Doses in One Month Storage at Room Temperature.

Irradiation Doses	**Microbial Count (CFU/g)**	
	0 month	**1 month**
0 kGy (Control)	1.83×10^4	Spoilt
3 kGy	0	1.53×10^6
5 kGy	0	0
10 kGy	0	0

Table 3: The Number of Bacterial Colonies in Irradiated Pre-Cooked Chicken Burgers with Different Doses in One Month Storage at Room Temperature.

Irradiation Doses	Microbial Count (CFU/g)	
	0 month	1 month
0 kGy (Control)	0	0
3 kGy	0	0
5 kGy	0	0
10 kGy	0	0

Table 4: The Number of Fungal Colonies in Irradiated Pre-Cooked Chicken Burgers with Different Doses In One Month Storage At Room Temperature.

Irradiation Doses	Microbial Count (CFU/g)	
	0 month	1 month
0 kGy (Control)	3.33×10^3	Spoilt
3 kGy	4.57×10^2	2.53×10^3
5 kGy	0	0
10 kGy	0	0

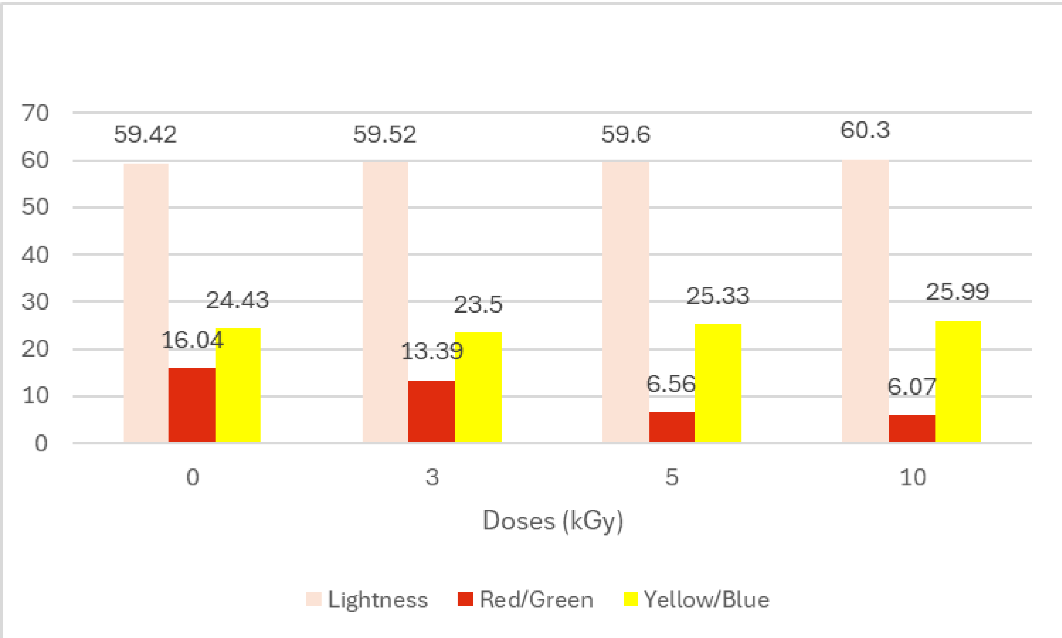

Figure 1: Lightness (L), Redness (A) And Yellowness (B) Values of Pre-Cooked Chicken Sausages Samples After Irradiated with Different Doses.

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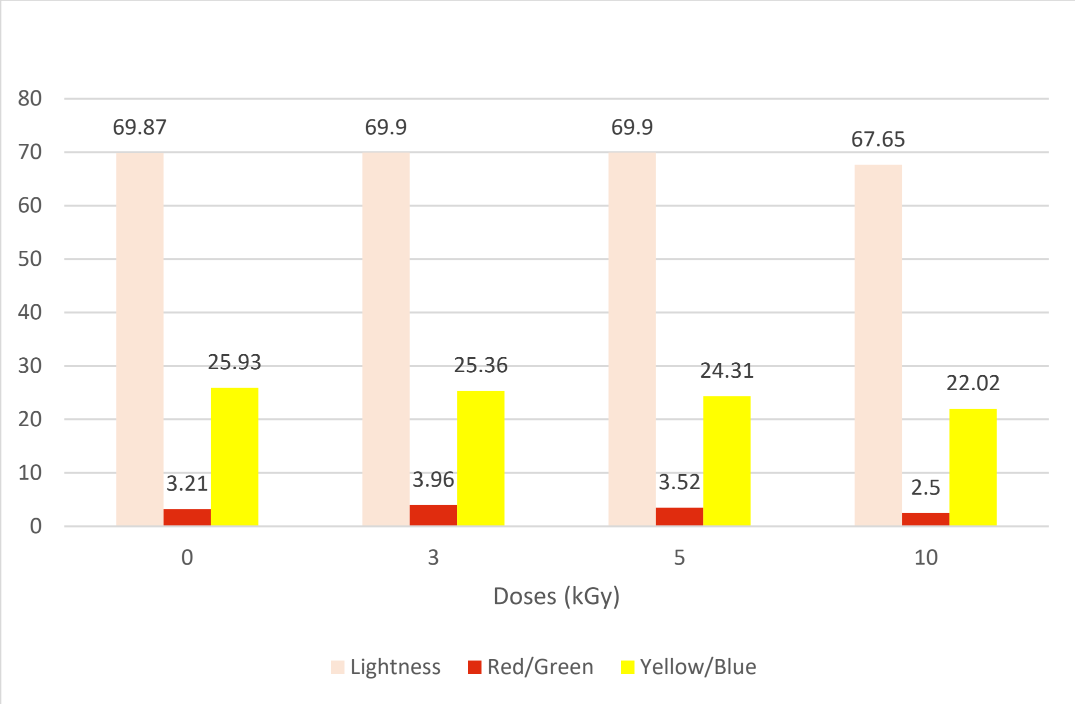

Figure 2: Lightness (L), Redness (A) And Yellowness (B) Values of Pre-Cooked Chicken Burgers Samples After Irradiated with Different Doses.

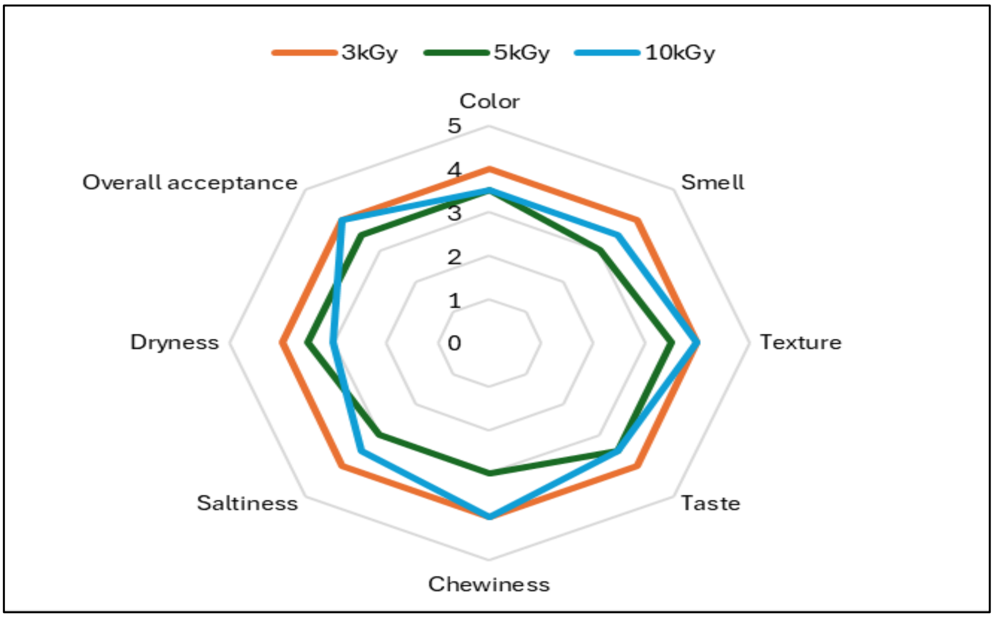

Figure 3: The Acceptance of Irradiated Pre-Cooked Chicken Sausages After One Month Storage at Room Temperature In Different Attributes Of Sensory Evaluation.

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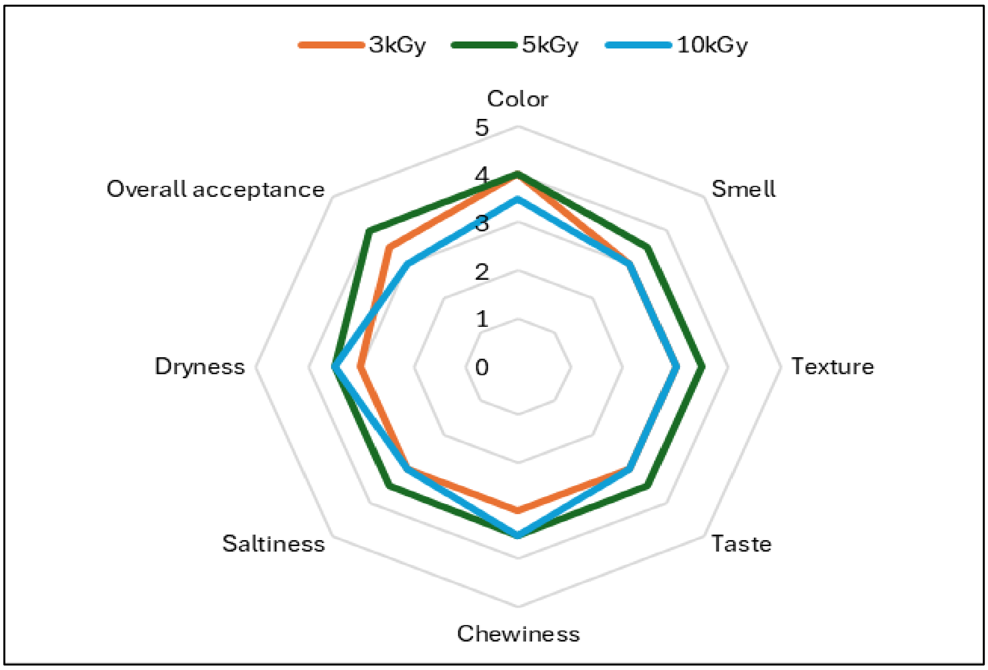

Figure 4: The Acceptance of Irradiated Pre-Cooked Chicken Burgers After One Month Storage at Room Temperature in Different Attributes of Sensory Evaluation.

Irradiation technology is known to be the most efficient way to eliminate pathogenic and spoilage microorganisms without deteriorating the nutritional and organoleptic qualities of food during storage (Kim et al., 2010). Irradiation can be continuously applied without being affected by the temperature, humidity, or pressure of the food sterilization process (Hwang et al., 2021). Lee et al., 2024 stated that it is also possible to increase energy efficiency and sterilize contaminating microorganisms in packaged foods. Irradiation can prolong the shelf life of food when microbial spoilage is a limiting factor (Hwang et al., 2015). The 1980 FAO/IAEA/WHO joint expert committee on the wholesomeness of irradiated foods (JECFI) concluded that all foods irradiated at doses up to 10 kGy did not pose toxicological hazards or nutritional or microbiological problems.

The purpose of sanitizing meat using irradiation is to ensure microbiological safety, parasite control, and extension of refrigeration shelf-life (Song et al., 2017). In addition, the application of radiation technology in the manufacture of meat products ensures meat hygiene and safety (Choi et al., 2016). New technologies for maintaining the freshness and sanitization of meat and meat products are being developed using various irradiation technologies; however, these technologies are not widely used in industry. Choi et al., 2016 pointed out that this is because there is still apprehension among consumers regarding irradiated food products because of their lack of understanding of the mechanism and characteristics of irradiation. The use of irradiation technology in the food industry requires more scientific research, development, and industrialization foundations for sound development, and it is necessary to establish new technologies that can contribute to food safety and public health improvement (Kim et.al 2024).

Food irradiation is non-thermal food preservation process. It is a treatment of food exposition on an amount of energy in the form of speed particles or rays. Depending on absorbed radiation dose, various effects can be achieved, resulting in reduced storage losses, extended shelf life and/or improved microbiological and parasitological safety of foods (Farkas, 2006). Food irradiation technology is being used in an increasing number of countries for decontamination and/or sterilization of dehydrated vegetables, fruits, meats, poultry, fish and seafood to improve product safety and shelf life (Ahmad Shah et al., 2014). Food irradiation may be achieved using low-dose, medium-dose, or high-dose levels of radiation. Low dose irradiation (< 2 kGy) is used to delay sprouting of vegetables and aging of fruits; medium dose (between 1 and 10 kGy) is used to reduce the levels of pathogenic organisms, similar to pasteurization; and high dose (>10 kGy) is used to achieve sterility of the product (Morehouse and Komolprasert, 2004).

Ionizing irradiation is one of the food preservation techniques with minimum interruption of to the functional, nutritional, and sensory properties of food products at lower doses. However, high-dose irradiation, especially higher than 10 kGy, can lead to physicochemical changes and significantly deteriorate sensory properties of foods (Miller, 2005; Kim et al., 2006). It is considered a more effective and appropriate method to enhance food stability and safety, when compared to other processing methods like heat and chemical methods (Arapcheska et al., 2020).

Conclusion

Pre-cooked chicken meat products samples irradiated with doses of 3 and 5 kGy were most preferred for most of the attributes. Irradiation with dose 5 kGy was suitable for pre-cooked chicken sausages and burgers to extend their shelf-life in room temperature for one month storage. These results demonstrated the ability of gamma irradiation for the decontamination of pre-cooked meat products and reliable process for food storage in commercial industry.

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Author Contribution Statement:	All authors contributed significantly to the development of this manuscript. Seri Chempaka Mohd. Yusof was responsible for the conceptualization, methodology, and overall supervision of the study. Mohd. Hafiz Abdul Nasir, Cosmos George and Ahsanulkhaliqin Abdul Wahab handled data collection, analysis, and interpretation of results. Seri Chempaka Mohd. Yusof contributed to the literature review, drafting, and critical revision of the manuscript. All authors read and approved the final version of the manuscript prior to submission.

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