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MICROBIOLOGICAL QUALITY AND ACCEPTANCE OF GAMMA IRRADIATED FERMENTED MUSHROOM AND CABBAGE DURING STORAGE

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Abstract:

For developing countries, safe shelf-stable foods without refrigeration would offer advantages. Gamma ray, an ionizing radiation is known to be a safe technology for treating food products in extending their shelf-life. Studies were carried out to overcome arisen problems of the safe shelf-stable food and to evaluate the suitability of irradiation in preserving local fermented mushrooms (Pekasam Cendawan) and local fermented cabbages. Generally, local fermented mushrooms can be kept in room temperature and under chilled condition only for one and three days respectively. Similarly, local fermented cabbages require chilled condition for storage to avoid the packages bloated upon displayed and storage. Fresh packed fermented products were obtained from local producers and irradiated at doses of 2.0 kGy, 5.0 kGy and 10 kGy, using 60Co gamma irradiation source at MINTec-Sinagama. The irradiated and non-irradiated samples were displayed at room temperature storage periods for 2 weeks, 1 month, 3 months and 6 months. Microbiological analysis was carried out to determine status of bacteria (Total Plate Count) and fungi counts. The results were expressed as colony forming units per gram (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 fermented products were determined through sensory evaluation by using 30 members (male and female) of untrained panellists. The fungal and

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microbial counts in both samples irradiated at 5 and 10 kGy were more lowered than samples irradiated at 2 kGy. After storage at 3 months, the fungal and microbial counts were increased in the both control samples of fermented mushrooms and cabbages but maintained low in both irradiated samples. The control samples of fermented mushrooms (not irradiated) were spoiled after displayed one day in room temperature and after chilled for 3 months. Both irradiated samples at 2 kGy and 5 kGy were more accepted in sensory evaluation especially the texture and taste and no significant changes ($P<0.05$) in lightness, redness, and redness of fermented cabbage samples during 3 months storage. However, fermented mushroom samples irradiated at 5 kGy become darker after 3 months storage. Irradiation reduced the bloatness in the packaged fermented cabbages by reducing the count of bacteria in the products. These results showed the ability gamma irradiation for decontamination of selected fermented food and reliable process for food storage in commercial industries.

Keywords:

Gamma, Irradiation, Mushroom, Microbial, Storage

Introduction

For developing countries, safe shelf-stable foods without the need for refrigeration would offer advantages. Irradiation offers a potential effort to enhance microbiological safety and quality of food through shelf-life extension. The benefits of irradiation as a sanitary treatment of many types of food are well known, some of which are applied commercially in several countries. 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 and Nam, 2004; Oluwakemi et al.,2018).

Various raw materials such as vegetables and animal origin are subjected to lactic acid fermentation which yields food products with high nutritional and dietary value. Fermented products are highly popular in Asian and African countries as the basic ingredients of the daily diet and lactic fermentation is a simple and often the only method for preservation of fruits and vegetables (Rhee et al., 2011; Tamang, 2012). Fermented vegetable such as cabbage has an important role in the diet and nutrition and has become popular throughout the world. However, it has a very short shelf life because its microbiological and enzymatic activity continue and result in a quality deterioration due to a sour and bitter taste, off-order and softening (Cheigh and Park, 1994; Songet al., 2004). In many regions of the world, the process of lactic fermentation is also traditionally used to preserve fruiting bodies of edible mushrooms. Mushrooms are appreciated for their organoleptic qualities as well as the presence of many different bioactive substances exhibiting healing and health-promoting properties (Jabłońska-Ryś et al. 2019). Edible mushrooms have a short shelf life due to rapid post-harvest changes. Therefore, lactic acid fermentation of wild and cultivated mushrooms is a cheap and efficient method of preservation. This method is in domestic use in Eastern Europe and in Asia, but only a limited number of studies in this field are known (Jabłońska-Ryś et al. 2016). Generally, local fermented mushrooms (Pekasam cendawan) can be kept in room temperature and under chilled condition only for one and three days respectively. Local fermented cabbages require chilled condition for storage to avoid the packages bloated with CO^2 gas generated upon displayed and storage. Therefore, an inactivation of fermentative microorganisms is essential for the

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preparation of shelf stable foods. Studies were carried out to overcome arisen problems of the safe shelf-stable foods and to evaluate the suitability of irradiation in preserving local fermented mushrooms (Pekasam Cendawan) and local fermented cabbages. A few problems faced by the industries in producing these fermented products are such as:

1) preservation using high temperature such as retort or canning technology will destroy the morphology and taste of the products.
2) packaging in cans, bottles and jars are heavy and need extra care during displaying and transportation.
3) these products must be kept in refrigerator when displayed and easily deteriorated when they left in room temperature for a day. It is very convenient if these products can be displayed on shelf at room temperature.
4) high cost in transportation to the other places since chilling facilities are needed.

Materials and Methods

Fresh packed fermented products were obtained from local producers and irradiated at irradiation doses of 2 kGy, 5 kGy and 10 kGy, using ^{60}Co 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 storage period of 3 months.

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 30^{o}C for 48 hours and Potato Dextrose Agar for molds (incubated at 30^{o}C for 5 days). The results were expressed as colony forming units per gram (cfu/g).

Colour changes of the products were recorded using Colorimeter (Minolta) with L, a, b values i.e. Lightness (L), redness (a) and yellowness (b). Acceptability of the irradiated fermented products were determined through sensory evaluation using 30 members (male and female) of untrained panellists. A 5-point hedonic rating scale was used with 5 points as the most acceptable and 1 point as the most unacceptable. The attributes evaluated were colour, aroma, shape, texture, taste, chewiness, juiciness and overall acceptance. Statistical analysis using ANOVA test and comparisons were made by Duncan’s multiple range tests.

Results and Discussion

Irradiation at 2 kGy reduced the fungal and microbial loads in irradiated local fermented cabbages (local kimchi) compared to the control samples (not irradiated). The fungal and microbial loads in samples irradiated at 5 and 10 kGy were more lowered than samples irradiated at 2kGy (Table 1 and 2). After storage at 3 months, the fungal and microbial loads were increased in the control samples but maintained low in samples irradiated at 2, 5 and 10 kGy.

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Table 1: The Number Of Fungal Colonies In Fermented Cabbages Irradiated With Different Doses And Storage Time.

Irradiation Dose kGy	Fungal count (cfu/g) 0 month	Fungal count (cfu/g) 3 months
0 (control)	2.4×10^{3}	3.6×10^{3}
2	5.4×10^{2}	7.4×10^{2}
5	3.2×10^{2}	4.6×10^{2}
10	6.4×10^{1}	8.1×10^{1}

Table 2: The Number Of Microbial Colonies In Fermented Cabbages Irradiated With Different Doses And Storage Time.

Irradiation Dose kGy	Microbial count (cfu/g) 0 month	Microbial count (cfu/g) 3 months
0 (control)	1.6×10^{3}	2.5×10^{3}
2	7.3×10^{2}	9.2×10^{2}
5	5.6×10^{2}	7.4×10^{2}
10	5.0×10^{1}	6.1×10^{1}

There were significant changes in the morphology of in local fermented cabbages that irradiated at 2, 5 and 10 kGy. Samples irradiated at 2 and 5 kGy were more accepted in sensory evaluation especially the texture and taste (Figure 1). Samples irradiated at 10 kGy were totally changed in the texture and taste acceptance. However, there were no significant changes ($P<0.05$) in lightness, redness and redness of all samples after 3 months storage (Figure 2).

The control samples generate gases during display and storage and the packaging became bloated. Some of fermented products generate gases during display and storage and the packaging became bloated and burst at certain time. This is because the growth of lactic acid bacteria in the fermented products keep increasing and emit gases (Hong-sun et al., 2003). In this studies irradiation at 2, 5 and 10 kGy prevented the bloat in the packaging of fermented cabbages by reducing the count of bacteria in the products. Gamma radiation can be applied to improve the quality and shelf-life and to control the ripening process of kimchi products (Kim, Yook, & Byun, 2004).

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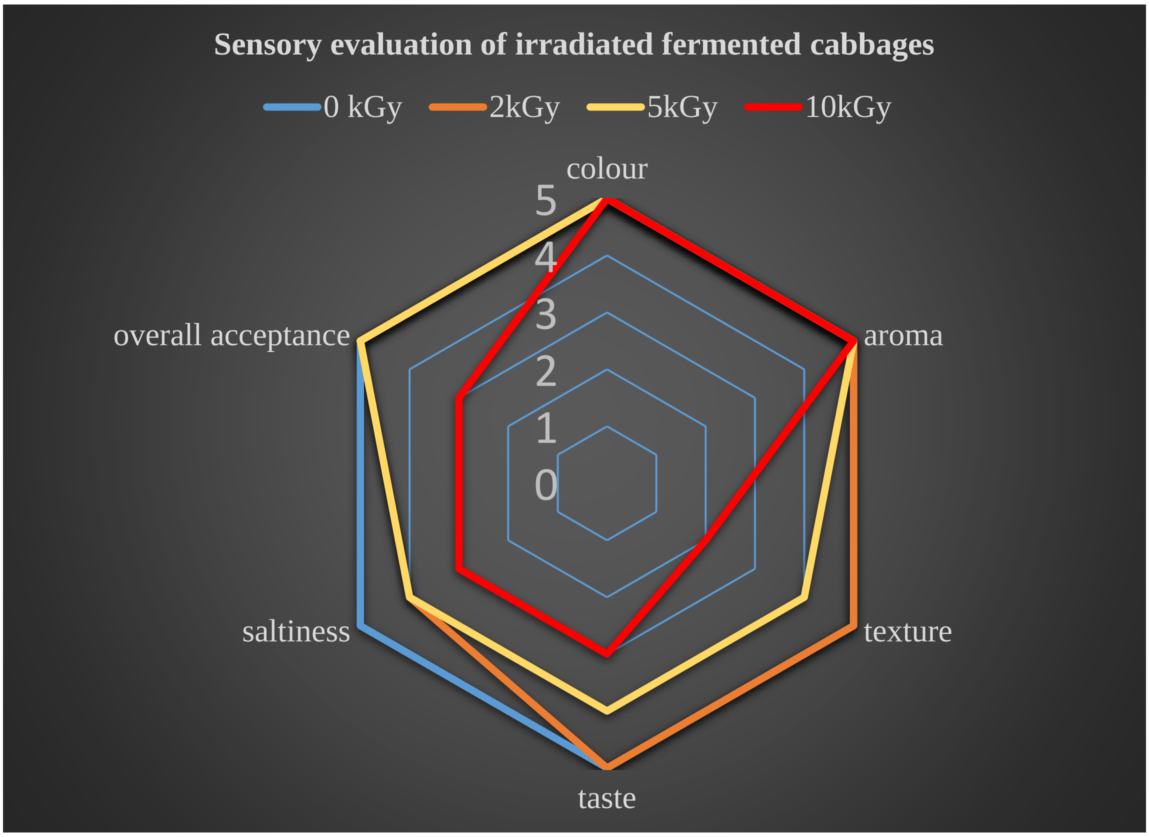

Figure 1: Sensory Evaluation Of Irradiated Fermented Cabbages Samples After 3 Months Storage.

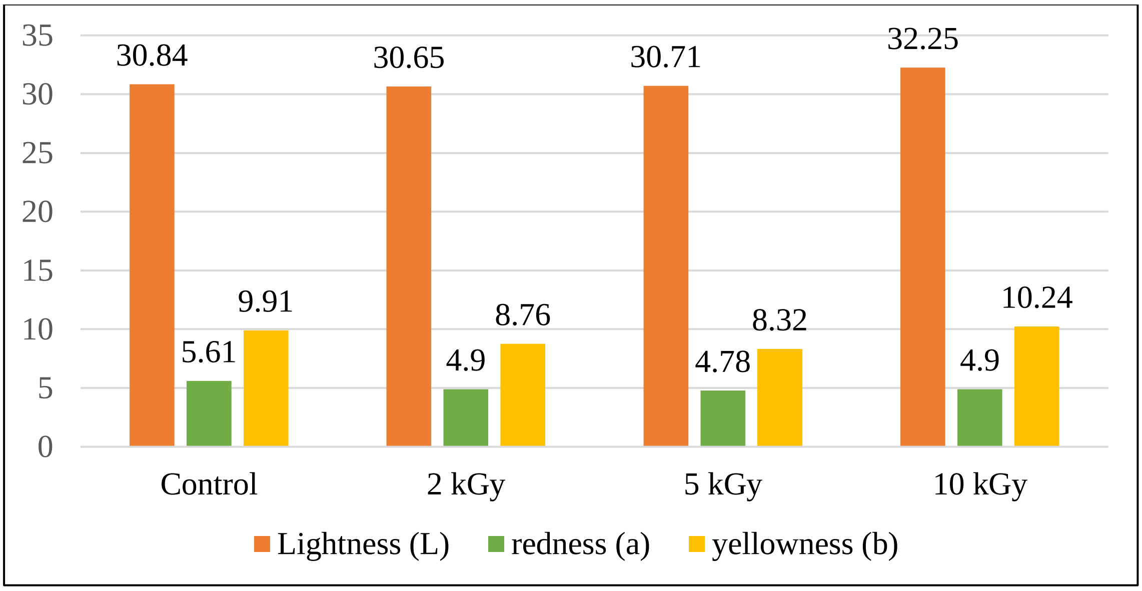

Figure 2: Lightness (L), Redness (a) and Yellowness (b) Values of Fermented Cabbages Samples After 3 Months Storage.

Irradiation at 5 kGy reduced the fungal and microbial loads in irradiated local fermented mushrooms (Pekasam cendawan) samples compared to the control samples (not irradiated) and

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maintained low after 3 months storage (Table 3 and 4). The control samples (not irradiated) were spoiled after being displayed one day in room temperature and the fungal and microbial loads increased and spoiled after being kept in chilled temperature for 3 months.

Table 3: The Number Of Fungal Colonies In Irradiated Local Fermented Mushrooms (Pekasam Cendawan) With Different Doses And Storage Time.

Irradiation Dose kGy	Fungal count (cfu/g) 0 month	Fungal count (cfu/g) 3 months
0 (control)	2.7×10^{3}	3.8×10^{5}
2	4.3×10^{2}	9.2×10^{3}
5	1.1×10^{2}	1.2×10^{3}
10	1.3×10^{2}	1.5×10^{3}

Table 4: The Number Of Microbial Colonies In Irradiated Local Fermented Mushrooms (Pekasam Cendawan) With Different Doses And Storage Time.

Irradiation Dose kGy	Microbial count (cfu/g) 0 month	Microbial count (cfu/g) 3 months
0 (control)	3.6×10^{3}	8.9×10^{5}
2	2.8×10^{2}	7.4×10^{3}
5	2.1×10^{2}	1.8×10^{3}
10	1.1×10^{2}	1.4×10^{3}

There were significant changes in the morphology of control (not irradiated) being kept chilled and irradiated local fermented mushroom (Pekasam cendawan) samples after 3 months storage. Control samples were spoiled after displayed and stored one day in room temperature and cannot proceed for sensory evaluation. Samples irradiated at 2 and 5 kGy were more accepted in sensory evaluation especially the texture and taste. However, samples irradiated at 10 kGy were not acceptable due to changes in texture (soften) and taste (Figure 3). Samples irradiated at 5 and 10 kGy become darker after 3 months storage (Figure 4).

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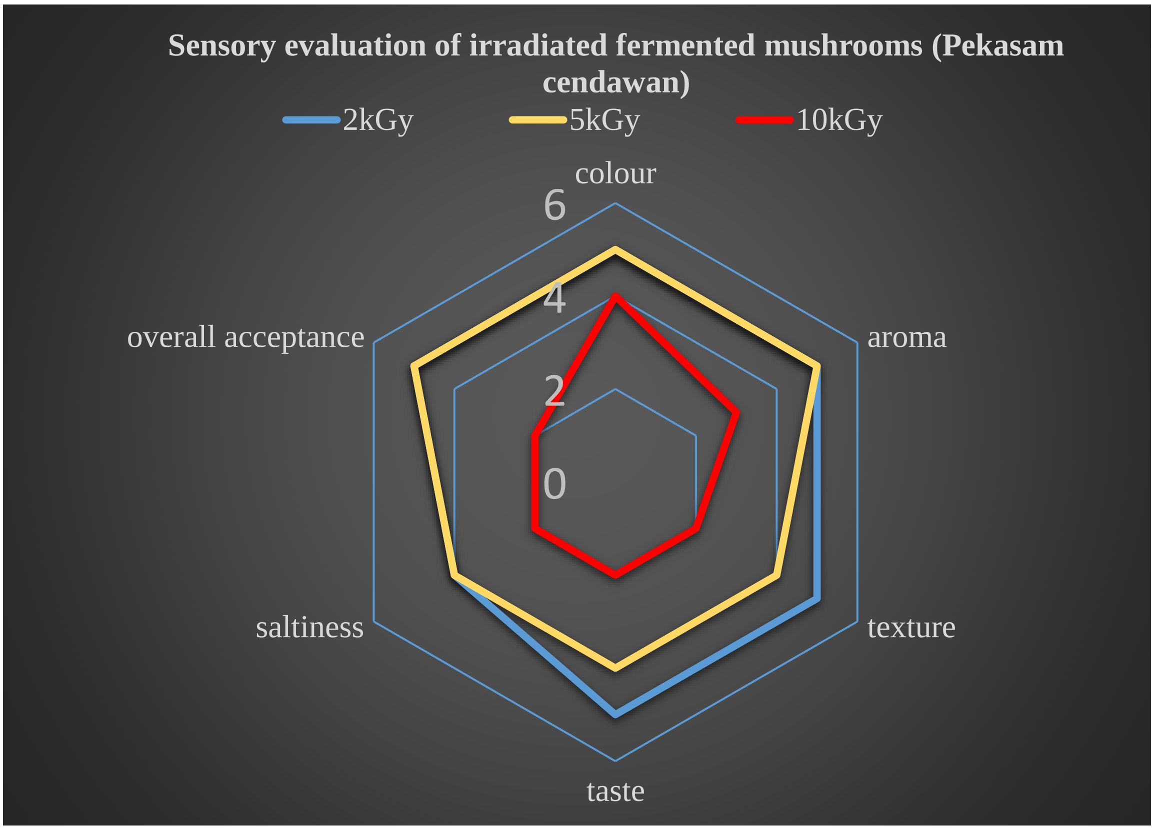

Figure 3: Sensory Evaluation Of Irradiated Fermented Mushrooms (Pekasam Cendawan) Samples After 3 Months Storage.

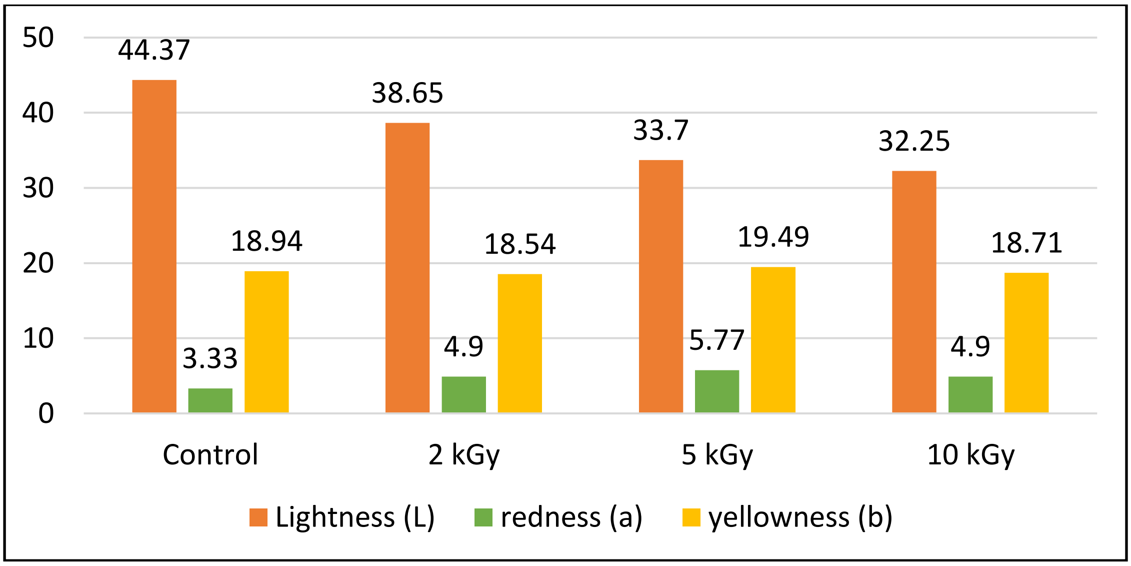

Figure 4: Lightness (L), Redness (a) and Yellowness (b) Values of Fermented Mushrooms (Pekasam Mushrooms) Samples After 3 Months Storage.

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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 effect 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).

For the treatment of food, the following ionizing radiations have been approved: gamma radiation from cobalt-60 (60Co) with maximum energy of 1.17 and 1.33 MeV, and cesium-137 (137Cs) with energy of 0.662 MeV; accelerated electrons (forming electron beams) with a maximum energy of 10 MeV and X rays with a maximum energy of 5 MeV (Codex Alimentarius, FAO/WHO, General Standard for Irradiated Foods, 2003).

The safety of irradiated foods for human consumption has been questioned because ionizing radiation can lead to chemical changes. The wholesomeness of irradiated foods has, therefore, been the subject of considerable national and international research, which has been reviewed and evaluated by joint expert committees of the International Atomic Energy Agency (IAEA), the World Health Organization (WHO), and the Food and Agricultural Organization (FAO) of the United Nations. These expert groups have uniformly concluded that the food irradiation process does not present any enhanced toxicological, microbiological, or nutritional hazard beyond those brought about by conventional food processing techniques (Diehl, 1995). These organizations, along with the Codex Alimentarius Commission and numerous regulatory agencies, have endorsed the safety of food irradiation, providing that Good Manufacturing Practices (GMPs) and Good Irradiation Practices (GIPs) are used.

Irradiation is an effective form of food preservation that extends the shelf life of the food and therefore reduces the spoilage of food. The process also benefits the consumer by reducing the risk of illnesses caused by foodborne diseases. 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).

Earlier studies have been carried out to control the fermentation process using various treatments such as high pressure treatment (Shon & Lee, 1998), heat treatment (Pyun et al. 1983), antimicrobial agents (Han & Kang, 2004), chemical additives (Kim & Hahn, 2003) and microbial additives (Jang et al., 2015). However, these methods could not meet perfect acceptable. Although they could retard the fermentation slightly, it is difficult to control the microbial and enzymatic activities during storage, distribution and to keep the product intact (Jeong et al, 2020). Food irradiation is an efficient method to eliminate the microorganisms in various fermented foods without product damage. These results imply that gamma irradiation can enhance the microbiological safety and shelf-life of fermented foods and decrease the

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initial concentration of microorganisms without adverse effects on quality. Results showed that these fermented products can be displayed or kept at room temperature for 1 month to 3 months as maximum limits for storage. This can be seen that after 2 months storage the microbial and fungi counts were increased and higher after 3 months.

Food irradiation offers a potential to enhance microbiological safety and quality of food through shelf-life extension. It is considered a more effective and appropriate method to enhancefood stability and safety, when compared to other processing methods like heat and chemical methods (Arapcheska et al., 2020).

Conclusion

Irradiation at dose 2 and 5 kGy was suitable in preserving local fermented mushrooms (Pekasam Cendawan) and local fermented cabbages as shelf stable products and accepted in morphology and sensory evaluation. These products can be displayed or kept at room temperature for 1 to 3 months (maximum). These results showed the ability of gamma irradiation for decontamination of selected fermented food and reliable process for food storage in commercial industries. Irradiation offers a potential effort to enhance microbiological safety and quality of food through shelf-life extension.

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