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DETERMINATION OF THE MICROBIOLOGICAL QUALITY AND ACCEPTANCE OF SELECTED IRRADIATED PERISHABLE FOOD PRODUCTS DURING STORAGE

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Abstract:

Food products such as bread, cakes and other delicacies are highly perishable products which are mainly deteriorate due to staling, moisture loss and microbial spoilage. More than 90% of mould contamination occurs during cooling, slicing, or wrapping operations. Studies were carried out to overcome arisen of the safe shelf-stable food and to evaluate the suitability of irradiation in preserving local sliced breads and bahulu cakes. Generally, these food products can be kept in room temperature only for one or two weeks respectively. Fresh packed 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 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. Results showed that irradiation at 2 kGy reduced the microbial loads (bacterial and fungal colonies) in the irradiated samples and no presence of microbes after irradiated at 5 and 10kGy. Nevertheless, after 1 month of storage, the microbial load increased in the control samples but

International Journal of Innovation and Industrial Revolution
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remained low in the irradiated samples. Both samples irradiated at 2 kGy were more acceptable in sensory evaluation especially texture and taste and there was a significant change (P<0.05) in the lightness of the sample after irradiation. The samples become darker after irradiation at 10 kGy. These results demonstrated the ability of gamma irradiation for the decontamination of selected perishable food products and reliable process for food storage in commercial industry.

Keywords:

Gamma, Irradiation, Perishable Food, Microbial, Storage

Introduction

Food irradiation is closely related with nuclear technology, hence application of it must follow food regulation act 1985 where the related industry must gain permission from Ministry of Health Malaysia. In 2011, Malaysia have achieved one of the biggest achievements in this industry when Ministry Health of Malaysia have approved food irradiation process up to 10kGy through food irradiation regulation 2011. This rule and regulation have fully enforced in Malaysia since 2013 until now. Food irradiation technology involve exposing food product with ionizing radiation under controlled environment. This technology has been used widely as an alternative method to preserve food product by increasing food shelf-life without changing food original taste, color, texture and food’s nutritional content. Scientifically findings, show that food irradiation has the ability to increase food safety, reduce post-harvest lost and overcome the trade barriers.

Bread and cakes are highly perishable products that mainly deteriorates due to staling, moisture loss and microbial spoilage. More than 90% of mould contamination occurs during cooling, slicing or wrapping operations (Magan et al, 2003). There is increasing public concern about food preservatives and an urge to reduce their amounts exist in the food industry (Saranraj & Geetha, 2012), which affects bread production and also associated mould spoilage (Magan et al, 2012). The effectiveness of food preservation by ionizing radiation is very well documented (Josephson & Peterson 1983), and prestigious international organizations support its wholesomeness (WHO, 1989). 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). This study was carried out to determine the microbiological quality and acceptance of irradiated local sliced breads and bahulu cakes during storage. Generally, these food products can be kept in room temperature only for one or two weeks respectively. Bread and bahulu cakes only able to sustain not more than one week in room temperature make it as high perishable food product.

Gonzalez et al. (2017) had studied on shelf stable highly nutritive bread, formulated to cover nutritional requirements of people in need of an emergency staple food. The bread was irradiated to improve its sanitary quality and extend shelf life. Packed in polyethylene film and gamma irradiated at 6 kGy, it attained at least a six times shelf life extension, being stored

International Journal of Innovation and Industrial Revolution
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IJIREV
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during 43 days at room temperature while maintaining its sensory quality. This bread remained microbiologically safe for at least nine months.

Food stored in refrigerator can take up space and will be difficult during electric shortage especially during natural disasters such as floods, earthquakes and other emergencies. Thus, this preliminary study was conducted to gain early information about the suitability of bread and bahulu cakes to be irradiated and stored at room temperature.

Materials and Methods

Fresh packed sliced breads and bahulu cakes 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. The irradiated and non-irradiated samples were displayed at room temperature storage period of one month.

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°C for 48 hours and Potato Dextrose Agar for molds (incubated at 30°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 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 aroma, texture - firmness, texture - brittleness, taste 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 sliced breads and bahulu caked 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 one month, the fungal and microbial loads were increased in the control samples but maintained low in samples irradiated at 2, 5 and 10 kGy.

Table 1: The Number Of Bacterial Colonies In Breads And Bahulu Cakes Irradiated With Different Doses And Storage Time.

BAHULU		
Irradiation dose (kGy)	Bacterial counts (cfu/g) - 0 Day	Bacterial counts (cfu/g) -1 Month
0 (control)	2.96×10^6	9.00×10^6
2	1.33×10^6	2.00×10^6
5	0	0
10	0	0
BREAD		
Irradiation dose (kGy)	Bacterial counts (cfu/g) - 0 Day	Bacterial counts (cfu/g) -1Month
0 (control)	6.17×10^6	8.94×10^6
2	5.30×10^6	6.03×10^6

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5	3.30×10^6	4.10×10^6
10	1.27×10^6	1.9×10^6

Table 2: The Number Of Fungal Colonies In Breads And Bahulu Cakes Irradiated With Different Doses And Storage Time.

BAHULU		
Irradiation dose (kGy)	Fungal counts (cfu/g) - 0 Day	Fungal counts (cfu/g) -1 Month
0 (control)	2.96×10^6	9.00×10^6
2	2.00×10^6	1.33×10^6
5	0	0
10	0	0
BREAD		
Irradiation dose (kGy)	Fungal counts (cfu/g) - 0 Day	Fungal counts (cfu/g) – 1 Month
0 (control)	1.30×10^6	2.30× 106
2	1.00×10^6	1.40 × 106
5	0	0
10	0	0

There were significant changes in the morphology of in samples that irradiated at 2, 5 and 10 kGy. Samples irradiated at 2 kGy were more accepted in sensory evaluation especially the texture and taste (Figure 1 and 2). Samples irradiated at 5 kGy and 10 kGy were totally changed in the texture and taste acceptance. It can be concluded by increasing doses, the dryness and the sweetness of the samples were also increased proportionally. Bread irradiated with higher dose experience bitter taste compared to bread exposed to lower radiation.

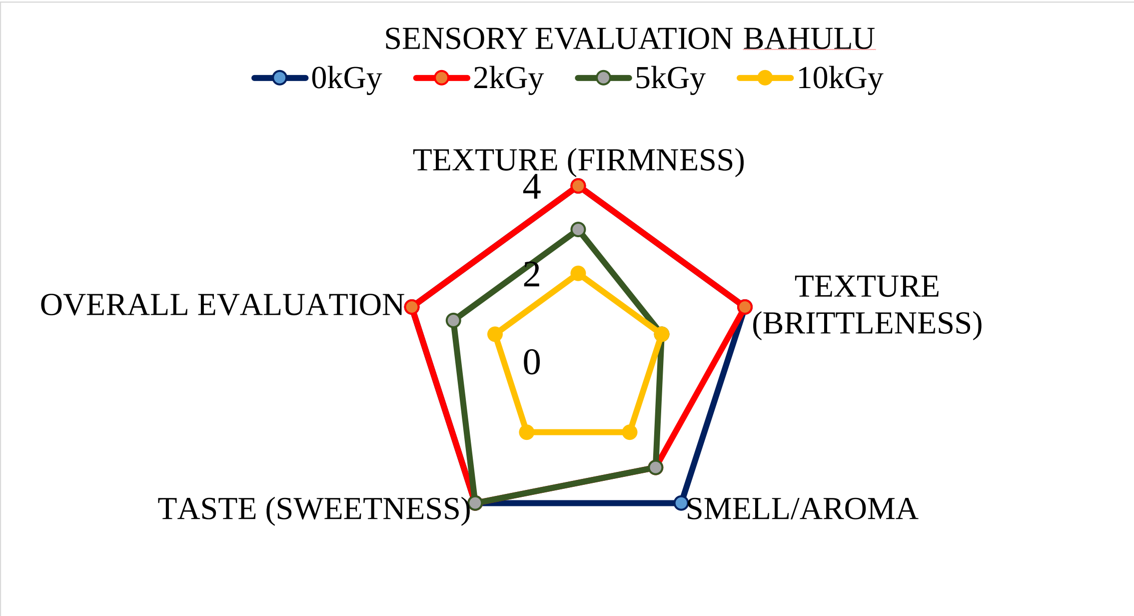

Figure 1: Sensory Evaluation Of Irradiated Bahulu Cakes Samples After 1 Month Storage.

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
Volume 6 Issue 19 (December 2024) PP. 140-151
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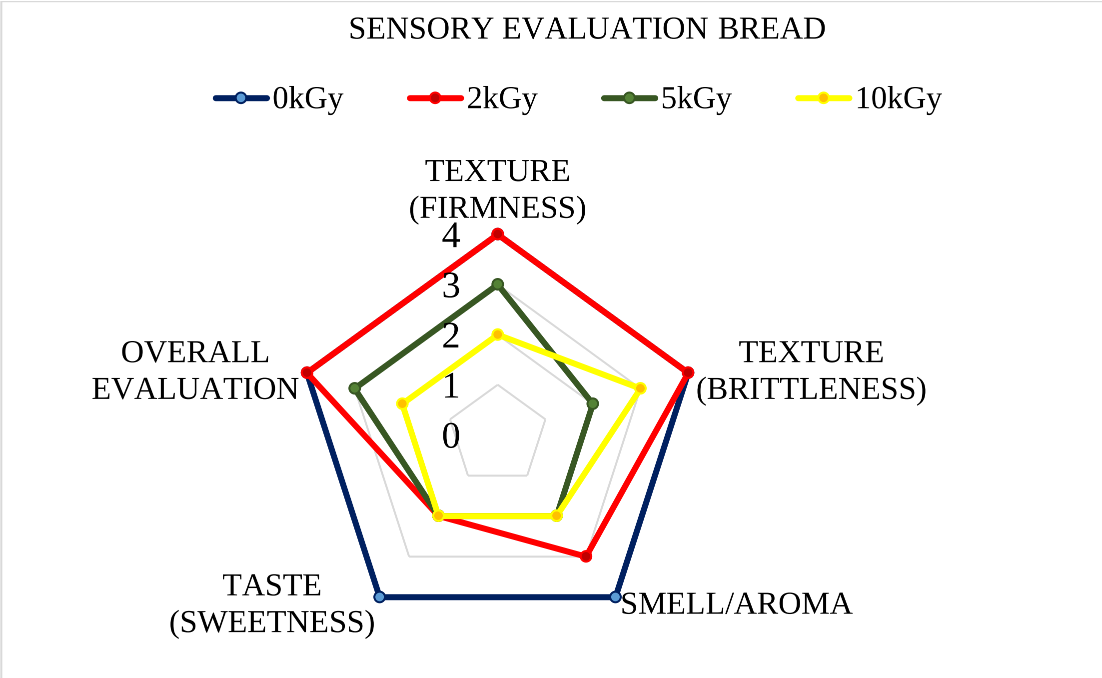

Figure 2: Sensory Evaluation Of Irradiated Sliced Breads Samples After 1 Month Storage.

There is no significant different for the L (lightness) of bahulu and bread irradiated with 2kGy of gamma with control in 0 day of storage. However, the L value decrease significantly when radiated with 5kGy and 10kGy in 0 day of storage for both bahulu and bread (Figure 3, 4, 5 and 6). This showed that high dose of radiation more than 5kGy have effect on the lightness of the food. For a value, the redness (a) and yellowness (b) of the irradiated bahulu cakes increased when the radiation dose increases during the 0 day of storage. The yellowness (b value) of the bahulu cakes increased after one month storage meanwhile there was no significant changes of yellowness of irradiated bread samples after 1 month storage.

From the result it can be concluded that increased radiation doses will decrease the overall sensory acceptance. This show that, radiation dose has effect on the sensory aspect of these samples. This result supported by Bandyopadhyay, et al. (2020) from his experiment when food irradiated with 5 kGy of gamma radiation reduced the firmness of the food. Other than that, it can be concluded that increased irradiation dose increased the dryness and sweetness of these bahulu cake samples. Bread irradiated with higher dose experience bitter taste compared to bread exposed to lower radiation. 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, higher dose of irradiation, especially higher than 10 kGy, can lead to physicochemical changes and significantly deteriorate sensory properties of foods (Miller, 2005; Kim et al., 2006). 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

International Journal of Innovation and Industrial Revolution
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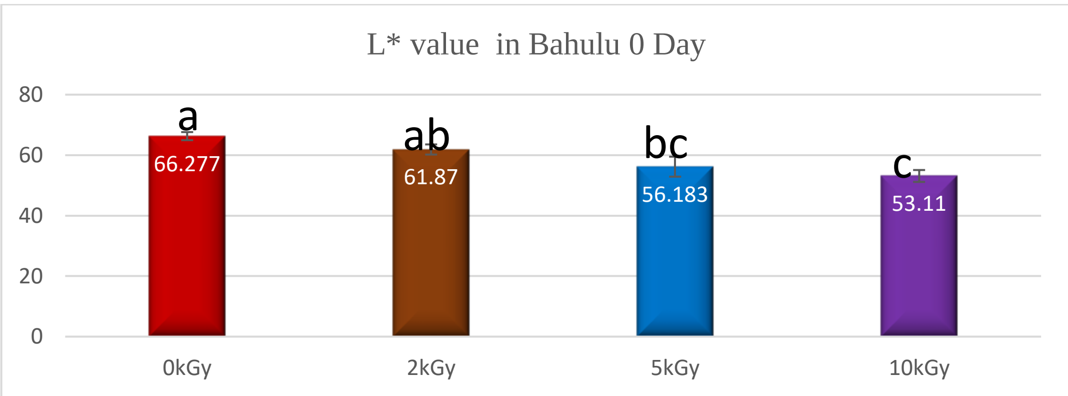
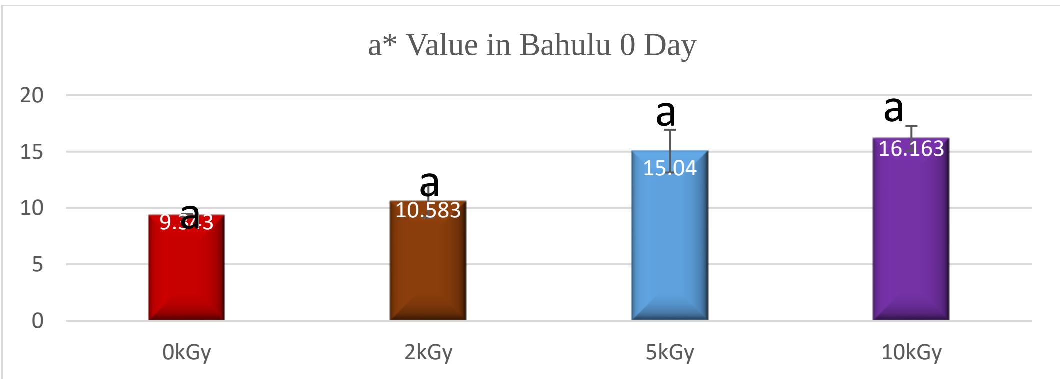
vegetables, fruits, meats, poultry, fish and seafood to improve product safety and shelf life (Ahmad Shah et al., 2014).

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.

Applications of food irradiation are usually classified by the level of dose applied to the food. In general, when dose is less than 1 kGy, it is called a low-dose irradiation process. When dose ranges between 1 and 10 kGy, it is a medium-dose process, and when dose is greater than 10 kGy, it is considered a high-dose irradiation process (Loaharanu, 2003; Miller, 2015). These processes have been studied and regulated in a very comprehensive manner by international and regional organizations (IAEA, 2004).





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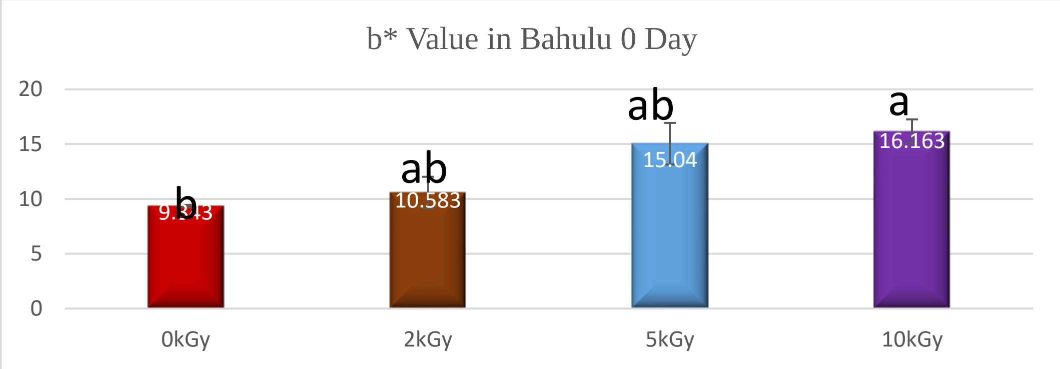
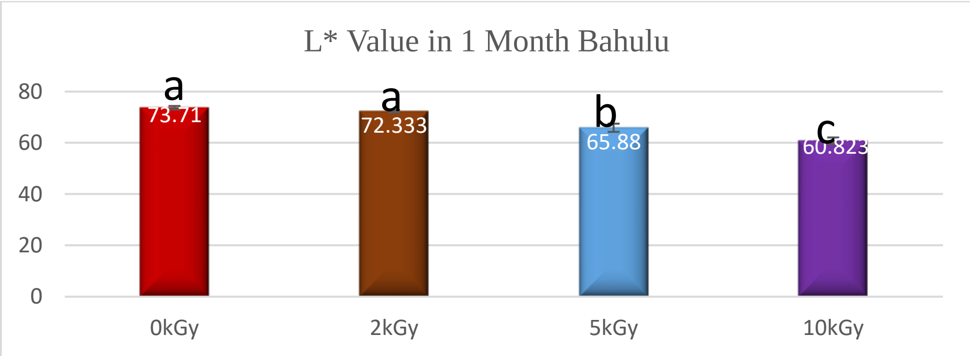
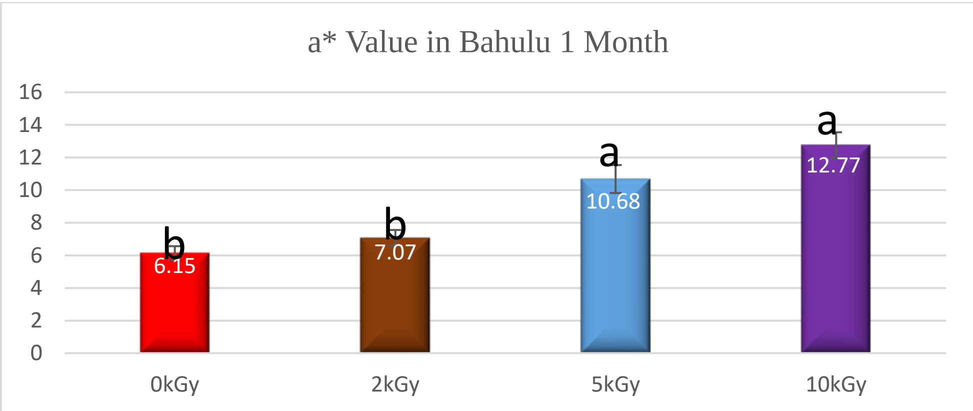


Figure 3: Lightness (L), Redness (a) and Yellowness (b) Values Of Bahulu Cakes Samples After Irradiated With Different Doses.





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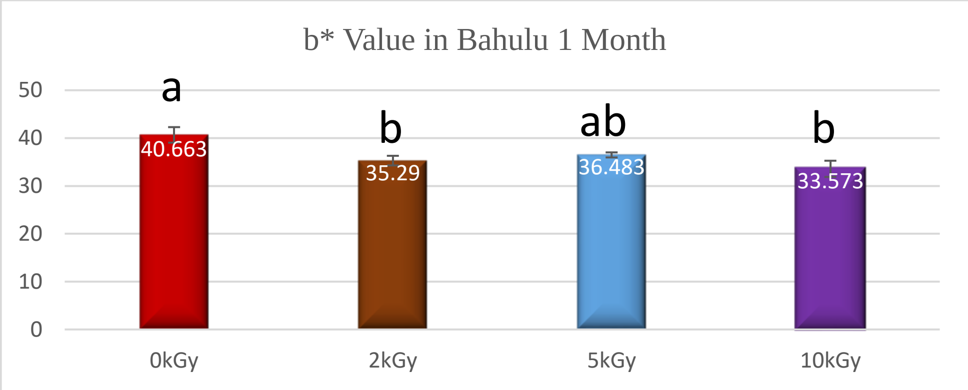
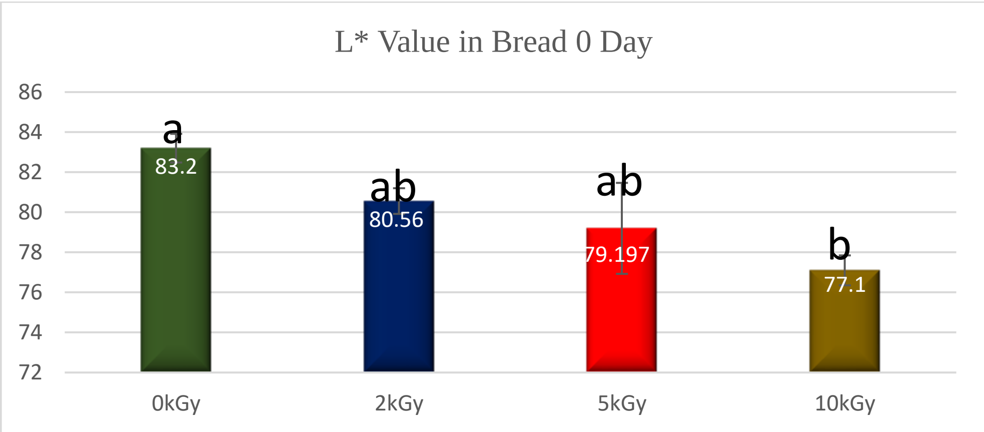
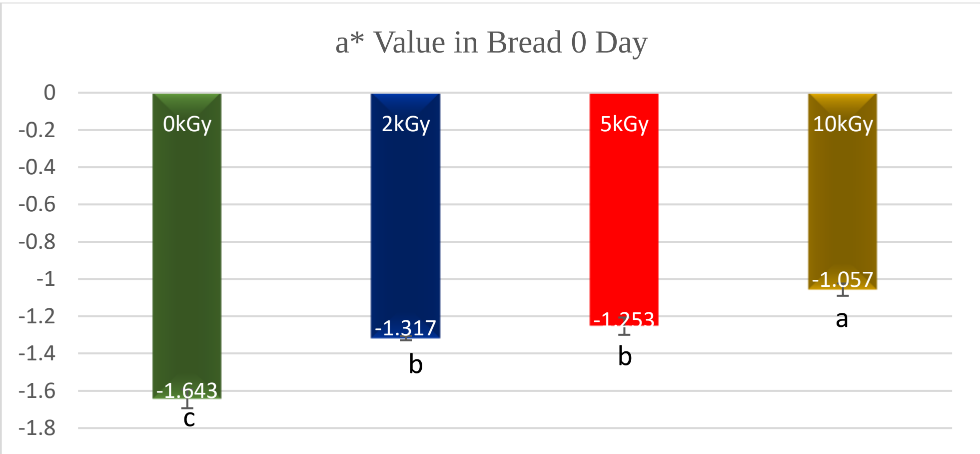


Figure 4: Lightness (L), Redness (a) and Yellowness (b) Values Of Bahulu Cakes Samples After Irradiated With Different Doses After Storage In 1 Month.





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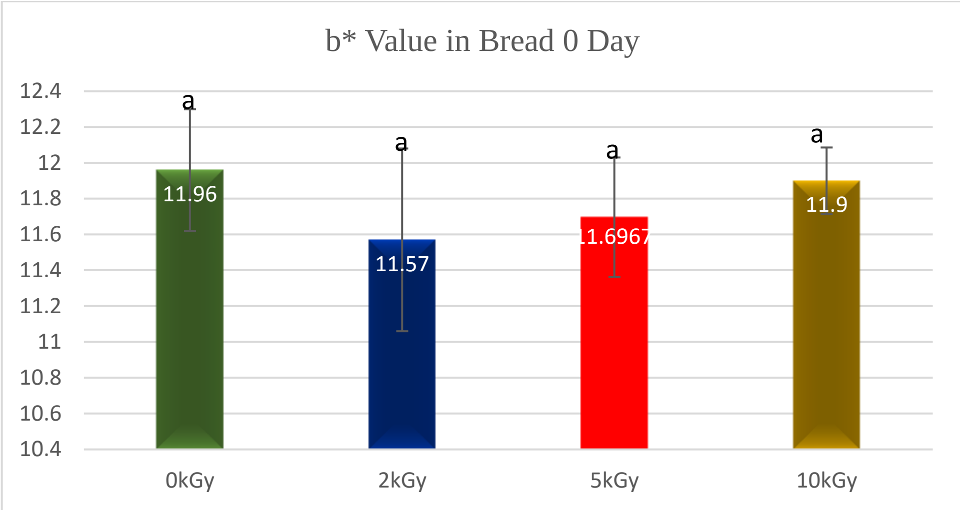
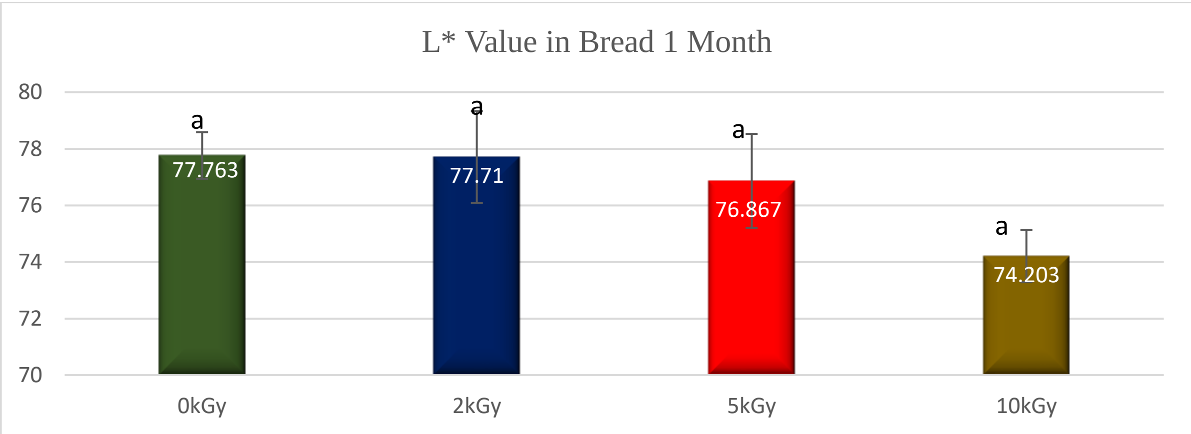
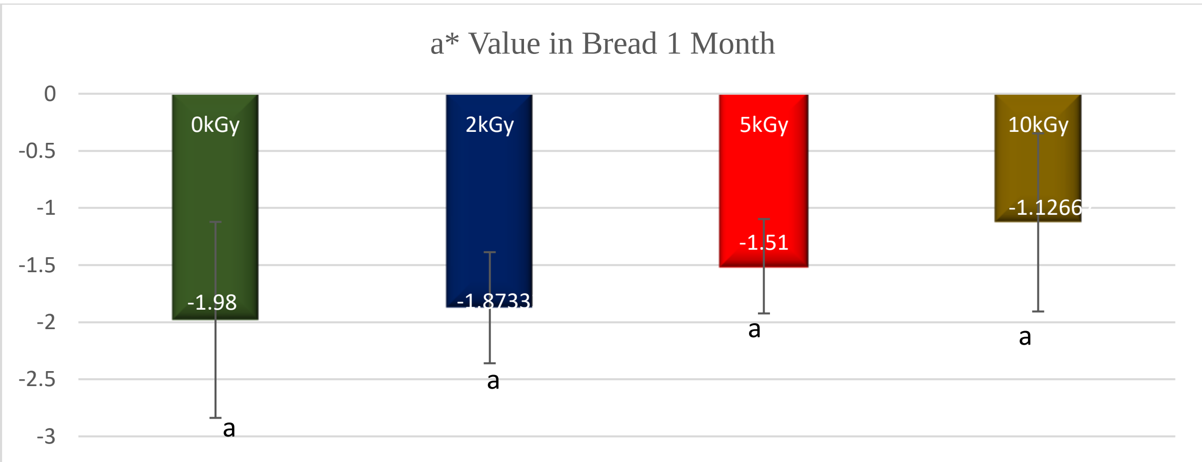


Figure 5: Lightness (L), Redness (a) and Yellowness (b) Values Of Bread Samples After Irradiated With Different Doses.





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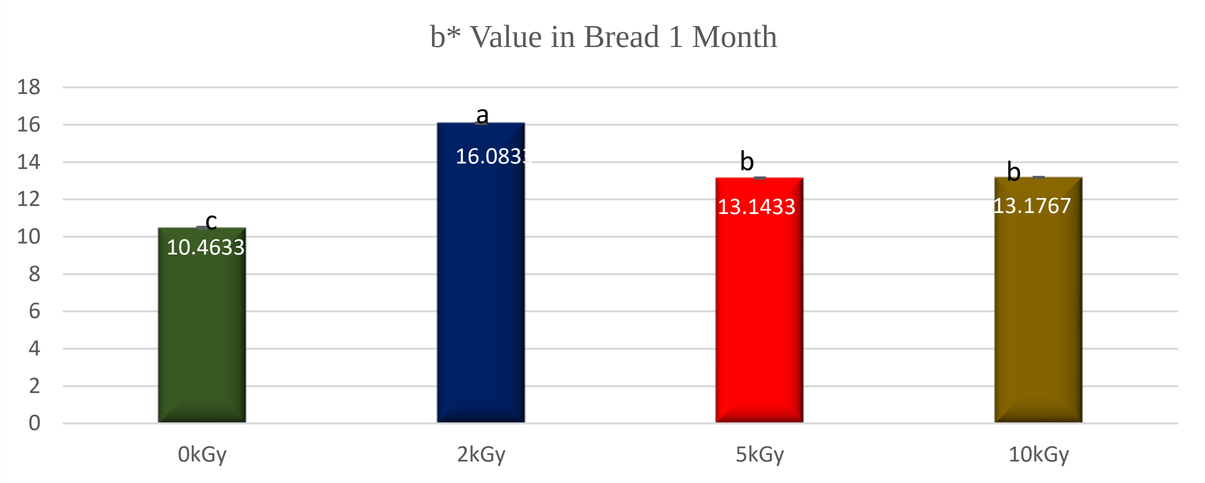

Figure 6: Lightness (L), Redness (a) and Yellowness (b) Values Of Bread Samples After Irradiated With Different Doses After Storage 1 Month

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).

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). 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 enhance food stability and safety, when compared to other processing methods like heat and chemical methods (Arapcheska et al., 2020). Gamma irradiation with its enormous attributes could be employed in food manufacturing industries to enhance product quality and shelf life.

Hamza et al. (2016) investigated the effects of gamma irradiation on microbial of white sandwich bread. Three different brands were irradiated using gamma radiation doses of 0.0, 0.2, 0.3, 0.4 and 0.5 kGy. Results show that 0.2 to 0.5 kGy gamma radiation exposure to the bread has the potential of eliminating or at least minimizing the ecology of spoilage-causing

Volume 6 Issue 19 (December 2024) PP. 140-151
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microorganisms in the bread. It is concluded that gamma irradiation could serve as an effective method in extending the shelf life of white sandwich bread.

Sirisoontaralak et al. (2017) reported. Reduction of specific volume, hardness, springiness, chewiness and crumb yellowness was noticed after irradiation at 2–10 kGy, whereas crust yellowness and peroxide values increased. Panelists could detect a decline in chiffon cake qualities, especially odor and texture. Gamma irradiation at 4 kGy, with or without 1.5 g/kg calcium propionate, effectively extended the shelf life of chiffon cake to 90 days without mold growth detection. However, storage of no longer than 75 days was recommended when oxidative rancidity was concerned.

In this study, both samples of bread and bahulu cakes irradiated at 2 kGy were more acceptable in sensory evaluation especially texture and taste and there was a significant change ($P<0.05$) in the lightness of the sample after irradiation. The samples become darker after irradiation at 10 kGy. These results demonstrated the ability of gamma irradiation for the decontamination of selected perishable food products and reliable process for food storage in commercial industry.

Conclusion

Irradiation at dose 2 kGy was suitable and recommended in preserving local perishable food products such as bread and bahulu cakes and was accepted in morphology and sensory evaluation. Therefore, any food industry that interested to use this technology need to improvise their formulation in order to maintain the originality acceptance of the product. These products can be displayed or kept at room temperature in maximum one month storage. These results showed the ability of gamma irradiation for the decontamination of selected food and reliable process for food storage in commercial industry.

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