



Potential irradiation of *Asam Keumamah* as an emergency food alternative

Potensi iradiasi Asam Keumamah sebagai alternatif pangan darurat

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Abstract

Emergency food is a safe and highly nutritious processed food product intended for the victims of natural disasters. Various food product assistance provided after a disaster is expected to meet the needs, but some cannot be stored for long. This study aimed to determine the potential of irradiated *Asam Keumamah* as an alternative emergency food. This experimental study used a completely randomized design (CRD) on *Asam Keumamah* samples that had been irradiated with five doses and stored for 30 days. *Asam Keumamah* was processed at the Food Technology Laboratory, Nutrition Department of Aceh Polytechnic, in 2022. Irradiation was carried out at the Merah Putih Gamma Irradiator in South Tangerang. The Total Bacteria Test was conducted at the BPBAP-UB Laboratory, Aceh Besar, and the Proximate Test was conducted at PPSHB, IPB Bogor. Statistical analysis used ANOVA and Kruskal-Willis and post hoc tests using Duncan at 95% CI. The results showed that the total bacterial counts of *Asam Keumamah* irradiated with doses of 0, 30, 40, and 50 kGy were 15, 15 CFU/g and 2.5 CFU/g, respectively. Irradiation dose of 0-20 kGy did not significantly affect the proximate content of irradiated *Asam Keumamah* ($p > 0,05$). Irradiation doses of 30, 40, and 50 kGy significantly affected the fat and carbohydrate content of *Asam Keumamah* ($p < 0,05$). In conclusion, irradiated and vacuumed *Asam Keumamah* is more durable and can be recommended as an alternative post-disaster emergency food.

Keywords: *Asam Keumamah*, bacteria, irradiated, proximate level

Abstrak

Pangan darurat merupakan produk pangan olahan yang aman dan bergizi tinggi ditujukan untuk korban bencana alam. Berbagai bantuan produk pangan yang diberikan pascabencana diharapkan mampu mencukupi kebutuhan, namun sebagian tidak dapat disimpan lama. Tujuan penelitian mengetahui potensi *Asam Keumamah* iradiasi sebagai alternatif pangan darurat. Penelitian eksperimental ini menggunakan Rancangan Acak Lengkap (RAL) pada sampel *Asam Keumamah* yang telah diiradiasi dengan lima dosis dan disimpan 30 hari. *Asam Keumamah* diolah di Laboratorium Teknologi Pangan, Jurusan Gizi Poltekkes Aceh, tahun 2022. Iradiasi dilakukan di Iradiator Gamma Merah Putih, Tangerang Selatan. Uji Total Bakteri dilakukan di Laboratorium BPBAP-UB, Aceh Besar, Uji Proksimat dilakukan di PPSHB, IPB Bogor. Analisis statistik menggunakan uji *Anova* dan *Kruskal-Willis*, serta *post hoc test* menggunakan *Duncan* pada CI 95%. Hasil penelitian menunjukkan total bakteri *Asam Keumamah* iradiasi dosis 0, 30, 40 dan 50 kGy berturut-turut 15 CFU/g, 15 CFU/g dan 2,5 CFU/g. Dosis iradiasi 0-20 kGy tidak berpengaruh nyata terhadap kadar proksimat *Asam Keumamah* iradiasi ($p > 0,05$). Dosis iradiasi 30, 40 dan 50 kGy berpengaruh nyata pada kadar lemak dan karbohidrat *Asam Keumamah* ($p < 0,05$). Kesimpulan, *Asam Keumamah* yang diiradiasi dan divacum lebih tahan lama sehingga dapat direkomendasikan sebagai alternatif pangan darurat pasca bencana.

Kata Kunci: *Asam Keumamah*, bakteri, kadar proksimat, iradiasi

Introduction

Natural disasters cause many people to flee, and they must be able to adapt to emergency conditions. The destruction of social facilities and infrastructure causes limited facilities to meet food needs. This condition does not guarantee that every individual gets adequate nutritional intake to survive (Tambur & Saputra, 2022).

Emergency food products are processed foods with high energy and nutrition intended for post-disaster refugees. This product can be used for 3 to 7 days and a maximum of 15 days until sufficient relief food is obtained (Syamsir, 2014). Emergency food products, including Asam Keumamah, can be developed as semi-solid foods. Tamarind products can be an alternative type of emergency food ready for consumption without going through the cooking process first. Keumamah is a local food easily found and can be processed into umamah acid to be consumed directly (Dewi, 2020).

Asam Keumamah is made from boiled and dried tuna (dried fish) cooked using kitchen spices with *Asam sunti*. *Asam sunti* is the result of processed star fruit salted daily during drying (Muzaifa, 2013). *Asam Keumamah* is a typical Acehese food that is very popular. The shelf life of *Asam Keumamah* is so short that it must be consumed immediately. In this study, *Asam Keumamah* was packaged in vacuum packaging and irradiated to prevent damage, retain nutrients, and last a long time. According to previous research, the shelf life of liquid smoked *Keumamah* products that are not vacuum packed is about 5–7 days. Smoked *Keumamah* products can last up to 30 days in a vacuum and irradiated packaging (Hadi et al., 2021).

Irradiation can inhibit microbial activity by damaging DNA to slow food decay (Bhalala, 2015). The combined irradiation technology does not cause radioactive properties without causing changes in the product's sensory quality to improve food safety (Muhardina, 2017). Therefore, examining the microbiological quality of irradiated Asam Keumamah as an alternative to emergency food is very important. This basic research will be followed by further research that can produce commercial tamarind products ready to eat as an alternative to emergency food after a disaster. Therefore, this study aims to

determine the potential of irradiated *Asam Keumamah* as an alternative to emergency food.

Methods

This experimental study used a Complete Randomized Design (CRD) with five irradiation dose treatments and four repeats on *Asam Keumamah* samples. The variables studied were total microbial and proximate levels of *Asam Keumamah*, consisting of ash, water, protein, fat, carbohydrate content, and peroxide. This research was conducted from August to October 2022. The research flow can be seen in Figure 1.

The main ingredients used in this study consisted of *Keumamah* (fish), red chili, cayenne pepper, *Asam sunti*, onion, garlic, curry leaves, salt, and oil. Microbes use agar nutrients for the Total Plate Count (TPC) test. Chemicals used for proximate tests include aquades, K₂SO₄, CuSO₄, H₃BO₃, NaOH, H₂SO₄, HCl, and BCG-MR indicators.

The equipment used in this study was knives, cutting boards, pans, blenders, stoves, and vacuum sealers. Equipment for proximate and microbiological tests is spatulas, mortars, pestles, Kjeldahl flasks, watch glass, electric stoves, distillation devices, analytical balances, beakers, test tubes, measuring cups, drip pipettes, fume hoods, erlenmeyer, funnels, burettes, Petri dishes, autoclaves, and incubators.

The formulation of Asam Keumamah was determined based on the research results (Nabila, 2017). The researcher has modified the formulation to achieve a taste that the panelists preferred. *Asam Keumamah* is made from 100 g of semi-dried *Keumamah* cleaned and thinly sliced. The fine seasoning consists of 20 g of tamarind or *Asam sunti*, 30 g of cayenne pepper, 25 g of red pepper, 10 g of garlic, and 40 g of onion. Sliced shallots, 10 g, and 3 g curry leaves were sauteed until fragrant, then added fine spices and 2 g turmeric powder, cooked over low heat until spices were cooked (oil separated from spices), put in sliced *Keumamah*, and stirred until cooked (dry and slightly browned color). Then, it is cooled and packaged in vacuum packaging (some microbiological tests are carried out).

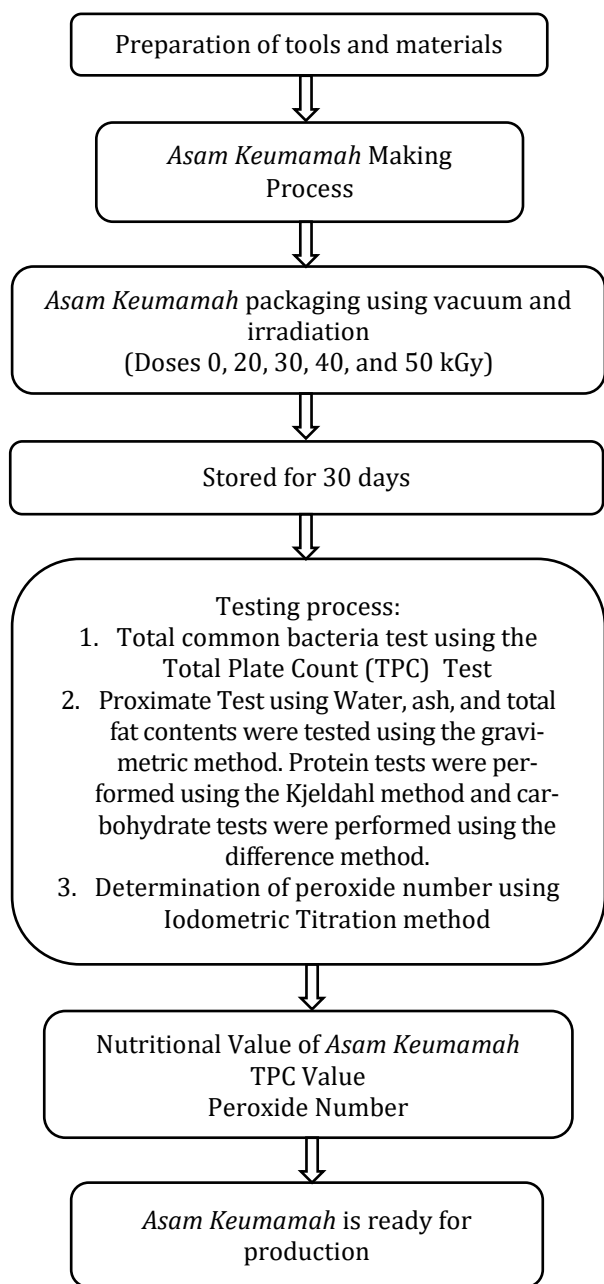


Figure 1. Research flow

Acid irradiation occurred at the Irradiator Gamma Merah Putih Puspittek area, Serpong, South Tangerang. Vacuum-packaged *Asam Keumamah*, after irradiation, is stored for 30 days at room temperature. A total bacterial test using ALT was carried out at BPBAP-UB Laboratory, Aceh Besar, and a proximate and peroxide test was carried out at PPSHB, IPB Bogor, after the shelf life. Non-parametric data were analyzed using the Kruskal-Willis test, parametric data using the ANOVA test, and the Duncan follow-up test at 95% CI. Ethical Clearance (EC) research obtained from the Ethics Commission for Health Assessment,

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Result and Discussion

Microbiology Test

The microbiological test results of *Asam Keumamah* before irradiation were $1,23 \times 10^4$ CFU/g (SNI 1×10^5 CFU/g), with a taste favored by the panelists. This Total Common Bacteria (TCB) value indicates that *Asam Keumamah* is safe for consumption. However, this *Asam Keumamah* cannot be stored for long because it can experience decay due to its high water content, so it cannot inhibit the growth of bacteria.

The TCB value of the microbiological test results of *Asam Keumamah* after being irradiated and stored for 30 days is much different from before. The average TCB results of irradiated *Asam Keumamah*, as shown in Table 1, showed the effect of irradiation and shelf life on the number of bacteria. The difference in the number of bacteria in unirradiated *Asam Keumamah* (0 kGy) is caused by several factors, especially the source of raw materials, the processing process, packaging, and shelf life. *Asam Keumamah*, stored for a long time in vacuum packaging at room temperature, still allows the growth of facultative aerobic bacteria.

Table 1. Average TPC (CFU/g) of Irradiated *Asam Keumamah* after 30 days of shelf life

Irradiation Dose	TPC±SD	Mean Ranks
0 kGy	$5,20 \times 10^5 \pm 5,28 \times 10^5$ ^a	17,13
20 kGy	$7,18 \times 10^5 \pm 11,92 \times 10^5$ ^a	15,88
30 kGy	$15 \pm 17,32$ ^b	7,25
40 kGy	$15 \pm 19,15$ ^b	7,25
50 kGy	$2,5 \pm 5,00$ ^b	5,00

Different characters in the notation column indicate a significant difference ($p < 0,05$)

Based on the results of the study (Table 1), the amount of TPC ($5,20 \times 10^5$ CFU/g) in *Asam Keumamah* without irradiation and stored for 30 days was slightly different from *Asam Keumamah* irradiated at a dose of 20 kGy, which is $7,18 \times 10^5$ CFU/g, The amount of TCB of *Asam Keumamah* irradiated at doses of 30 and 40 kGy was 15 CFU/g, and the dose of 50 kGy was 2,5 CFU/g, Irradiation treatment doses of > 30 kGy on *Asam Keumamah* can minimize the total

number of bacteria in the food. In emergency conditions, irradiated *Asam Keumamah* can be an alternative food rich in protein to fulfill the nutrition needs of disaster victims. Irradiated *Asam Keumamah* can be stored for 30 days at room temperature, making it easier to distribute to victims who need more time. Irradiated umamic acid is also very practical because it is vacuum-packed, safe for consumption, and does not require further processing (it can be consumed directly).

The irradiation dose of 20 kGy had no significant effect on the number of *Asam Keumamah* bacteria ($p > 0,05$). This is due to the high water content of *Asam Keumamah*, which affects the growth of bacteria in food stored in vacuum packaging. The good management of raw material sources also influences the amount of TPC in *Asam Keumamah*. The main raw material for *Asam Keumamah* is *Keumamah* (dried fish), which is traded in the traditional market in Banda Aceh City.

Wood fish sold freely in traditional markets are not packaged and left open, so high contamination levels from various sources can occur. Microbes contaminate *Keumamah* in the open during the storage period and marketing process due to exposure to dust, vectors, consumer hands, and the containers' cross-contamination.

Microorganism contamination in dried fish can occur during the initial process of making dried fish. Cob, tuna, and skipjack fish are mostly processed into dried fish by traders or residents around the Fish Auction Place (FAP/TPI) when the harvest is abundant. The drying occurs in open areas, even in front of shops, on the roadside, or around TPI. *Asam Keumamah* that has been cooked thoroughly can reduce the number of microbes, but the storage process can cause microbes that still survive to multiply (Hadi et al., 2021).

Asam Keumamah irradiated at doses of 30 and 40 kGy showed a TPC value of 15 CFU/g, far below the safe SNI threshold for consumers. Likewise, *Asam Keumamah*, with an irradiation dose of 50 kGy, shows that irradiation at ≥ 30 kGy significantly affects microbes ($p < 0,05$). Storage of products with high moisture content at room temperature can accelerate the growth rate of bacteria, especially mesophilic bacteria, so irradiated food needs to be stored in frozen conditions.

One of the purposes of using food processing technology is for gamma irradiation to reduce the number of pathogenic microbes. This technology impacts damaging bacterial DNA that contaminates food without affecting the sensory effects of the product. Gamma irradiation combined with frozen storage can inhibit enzymatic reactions and chemical reactions in microbial cells for maximum results. Disrupted enzymatic and chemical processes can prevent the process of DNA translation and transcription after exposure to gamma rays (Putri et al., 2015). According to the Regulation of the Minister of Health of the Republic of Indonesia Number 701/MENKES/PER/VIII/2009 concerning Irradiated Food, the dose limit of irradiation of processed foods of ready-to-eat animal origin is 65 kGy.

Average Total Plate Count (TPC) values have shown that treatment doses are most effective in lowering TPC at 50 kGy. The limit of microbial contamination in processed food is based on BPOM Regulation Number 13 of 2019 for Fish and Steamed or Boiled Fishery Products, with an ALT value of 10^5 colonies/g and an analysis method according to ISO 4833-1 and SNI 2332-3.

Excitation, ionization, and chemical changes can occur during gamma irradiation of foodstuffs. Excitation conditions are living cells that are sensitive to external influences. Ionization breaks down complex compounds or macromolecules into elements or free radical ions. Chemical changes can occur due to excitation, ionization, and chemical reactions during the irradiation process or after the completion of irradiation. DNA synthesis will be hampered due to chemical changes that occur in living cells; thus, it can interfere with cell division and the formation of new cells (Putri et al., 2015).

Irradiation doses of 3–7 kGy prevent food-borne diseases by damaging pathogenic bacteria such as *Salmonella* in fresh and frozen foods (Henriques et al., 2013). Sterile food with high irradiation doses can kill all microorganisms (Zhu et al., 2012).

Irradiation directly causes the rupture of chemical bonds in DNA and the indirect effects of reactive oxygen due to water radiolysis on cell membranes and chromosomes of microorganisms (Khazanah et al., 2017). Irradiation causes bacterial cells to be injured or

die due to destroying important macromolecules such as DNA, RNA, and proteins. The irradiation effect shows that *Salmonella* is more resistant than *E. coli* (Husna et al., 2017).

The difference in irradiation sensitivity is not only between species but also between strains. The size of the cell and the structural makeup of the DNA in the cell affect irradiation sensitivity. The irradiation resistance of bacterial species is strongly influenced by the ability of organisms to repair damage due to irradiation and physiological activities, such as the metabolic phases of organisms when irradiated separately (Kundu et al., 2014).

Jouki & Yazdi (2014) explain that irradiation extends the lag phase in microbial growth to affect a longer shelf life. Adding irradiation slows down the growth of bacteria and reduces their metabolic activity. The reduction of microbial TPC is influenced by its level of resistance. Bacterial growth conditions in the lag phase (when off) are more resistant to irradiation. When bacteria are in the log phase, they become more sensitive to gamma irradiation (Irmanita et al., 2016).

Long shelf life at room temperature can increase the number of microbes in the vacuum and irradiated *Sie Balu*. Adaptability, even in anaerobic conditions, causes the number of *Salmonella* to increase. The increase in *Salmonella* in irradiated *Sie Balu* is lower than in those not irradiated (Husna et al., 2017). The adaptation process is influenced by nutrients, temperature, water content, oxygen, and pH that

support bacterial growth (Valderrama et al., 2016).

Food product preservation technology with gamma-ray irradiation can extend the shelf life of products and minimize the number of pathogenic microbes. However, some pathogenic bacteria can survive, adapt, and multiply themselves post-irradiation. Therefore, the combination of gamma irradiation and vacuum packaging modified by regulating the gas levels in it inhibits the growth of pathogenic microbes and prevents unwanted changes in food products (Cahyani et al., 2015).

Irradiation and vacuum packaging can inhibit microbial growth and extend shelf life. Similarly, the combination of irradiation and cold splicing Cold storage is often utilized to increase product shelf life. At lower temperatures, the bacterial cell membrane changes fluidity. This effectively slows down the proliferation of putrefactive bacteria and pathogens (Raharja et al., 2018).

Proximate Test

The results of the proximate test showed that the ash and water content of *Asam Keumamah* did not experience significant changes after irradiation. At the same time, protein levels decreased slightly at irradiated doses of 30, 40, and 50 kGy. The fat content of *Asam Keumamah* decreased at a dose of ≥ 30 kGy, and vice versa, total carbohydrates increased at an irradiation dose of ≥ 30 kGy (Table 2).

Table 2. Test result proximate *Asam Keumamah* irradiation after a shelf life of 30 days.

Irradiation Dose	Proximate Value				
	Ash	Water	Protein	Fat	CH
0 kGy	4,68	51,63	19,37	18,60 ^a	5,74 ^a
20 kGy	4,47	51,28	19,42	19,88 ^a	4,95 ^a
30 kGy	4,66	52,34	18,72	15,49 ^b	8,81 ^b
40 kGy	4,47	51,10	17,93	17,72 ^{ab}	8,79 ^b
50 kGy	4,62	52,59	18,42	15,21 ^b	9,17 ^b
P value	0,25	0,17	0,19	0,01	0,00

Different character in the notation column indicates a significant difference ($p < 0,05$)

The results of the ANOVA analysis showed that the irradiation dose had no significant effect on ash content, water content, or *Asam Keumamah* protein ($p > 0,05$). Conversely, irradiation at doses of 30, 40, and 50 kGy affects the fat and carbohydrate levels of *Asam Keumamah* ($p < 0,05$).

Keumamah is a processed fish that is boiled and dried in the sun. The duration of boiling largely determines the protein content of *Keumamah*. The longer the boiling time of the *Keumamah*, the lower the protein content. The longer the processing time at high temperatures, the more protein will be damaged as water

comes from the fish meat (Amanullah et al., 2022).

Food irradiation has no impact on the nutrients contained in food products. Irradiation also does not affect food products' smell, taste, or shape. The energy absorbed in the irradiation process is lower than in the heating process. Therefore, the chemical characteristics of irradiated food are qualitatively less changed than the chemical characteristics of heated food (Indiarto, 2023). The results of this study showed that the high levels of ash, protein, and fat in *Asam Keumamah* were not much different before and after the irradiation process. Microorganisms need nutrients, namely protein in food, as a source of energy for their growth. Protein levels will decrease during the storage of foodstuffs. This is due to the growth and activity of microbes capable of degrading proteins (Misni et al., 2017).

Irradiation can inhibit the growth of putrefactive microbes that damage proteins and prevent the hydrolysis and decomposition of proteins. Irradiated energy can cause proteins to denature, so protein levels decrease (Putra, 2018). Irradiated *Asam Keumamah* fat levels at doses of 30, 40, and 50 kGy decreased because, during 30 days of storage, there was microbial growth, resulting in fat decomposition in food (Putra, 2018), proving a decrease in fat levels in irradiated mackerel. Radiation can cause hydrolysis reactions. Hydrolysis can occur because the water content of fat causes it to turn into free fatty acids and glycerol.

Food irradiation produces hydrogen, and hydrogen peroxide is produced in small amounts, even at high doses. The formation of hydrogen peroxide (an oxidizing agent) is a consideration in irradiated food safety, although it is comparable to the formation of highly reactive intermediate products. Hydroxyl radicals are strong oxidizing agents; hydrated electrons are strong reducing agents, and hydrogen atoms are less effective. Because all foodstuffs contain compounds that can be oxidized or reduced, reduction and oxidation reactions can occur (Itnaini, 2020).

The peroxide number of irradiated *Asam Keumamah* was kept for 30 days; the lowest at 30 kGy treatment was 3,98, while the highest peroxide number at 20 kGy treatment was 6,78. The lowest peroxide number (dose 30 kGy) exceeds the maximum

value of the "Standard Nasional Indonesia" or SNI, which is 2 meq/kg. The results of the ANOVA test showed a significance ($p=0,184$, $p > 0,05$), which proved that there was no real difference between the 5 treatments on peroxide numbers.

Table 3. Irradiated *Asam Keumamah* peroxide number

Irradiation dose	Peroxide number
0 kGy	3,77 meq/kg
20 kGy	6,78 meq/kg
30 kGy	3,98 meq/kg
40 kGy	6,15 meq/kg
50 kGy	4,15 meq/kg
p-value	0,184

Some studies of the irradiation of raw meat show that the irradiation process can increase the peroxide value and malonaldehyde levels of irradiated meat products compared to meat products without irradiation. Ionizing irradiation produces hydroxy radicals and can increase lipids' oxidation rate. The molecules become highly reactive and form ions or free radicals after absorbing ionization energy (Indiarto, 2023). Based on toxicological studies conducted by the International Food Irradiation Project (IFIP), irradiation techniques are safer than conventional processing techniques in food management. One of the in-vitro toxicity tests of *carp pepes* irradiated at 45 kGy is still safe for consumption after a shelf life of 6–12 months (Santosa, 2021).

This research has limitations on raw materials originating from traditional markets, so it does not guarantee the quality of *Asam Keumamah*. The high water content of *Asam Keumamah* treatment affects the less-than-optimal impact of irradiation technology on the elimination rate of microbes that contaminate *Asam Keumamah*.

Conclusion

Irradiation significantly affects the total microbial count and fat and carbohydrate levels of *Asam Keumamah*. The higher the dose of irradiation, the smaller the number of microbes in the food. *Asam Keumamah* can be stored for 30 days while maintaining its nutrients. *Asam*

Keumamah, irradiated and stored for 30 days, can be used as an alternative food during disaster emergencies.

Suggestion, *Asam Keumamah* is expected to be processed drier and packaged better so that, after irradiation, it can last longer. Irradiated *Asam Keumamah* can also be an alternative food for Acehnese people who carry out Hajj.

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