Journal of Science Innovare
https://journal.unpak.ac.id/index.php/jsi

Volume 07, Number 02, November 2024, Page 51-55
e-ISSN: 2615-3750 ; p-ISSN: 2615-3769

EFFECTS OF GUAVA JUICE (*psidium guajava l.*) ADDITION AT DIFFERENT CONCENTRATIONS ON EDAMAME YOGURT

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Article history: *received 15 October 2024; revised 20 October 2024; accepted 10 November 2024* *DOI: https://doi.org/10.33751/jsi.v7i2.12812*

Abstract. Edamame (Glycine max L. Merrill) is a functional food rich in plant-based protein that can serve as an alternative to animal protein sources. Its potential has led to the development of edamame yogurt, a lactose-free fermented product suitable for individuals with lactose intolerance. However, the characteristic "beany" flavor of soy-based products tends to reduce consumer acceptance. To improve sensory quality, taste, and nutritional value, guava (Psidium guajava L.) juice was incorporated into edamame yogurt formulations. This study aimed to evaluate the effects of varying guava juice concentrations on the organoleptic, physical, chemical, and antioxidant properties of edamame yogurt. The experiment employed a completely randomized design (CRD) consisting of four treatments with five replications, corresponding to guava juice concentrations of 0%, 15%, 25%, and 35%. Statistical analyses were conducted using One-Way ANOVA followed by the Duncan test to identify significant differences. The findings revealed that guava juice addition significantly influenced sensory attributes, physicochemical characteristics, and antioxidant activity. The 15% guava juice formulation was most preferred by panelists based on taste, aroma, and texture evaluation. The 25% guava concentration yielded optimal physical and chemical quality, as indicated by syneresis (2.19%), lactic acid content (0.016%), and a pH value of 4.0, consistent with Indonesian National Standards (SNI). Moreover, the highest antioxidant activity (83.55%) was recorded in the yogurt with 35% guava juice concentration. Overall, these results demonstrate that guava juice supplementation enhances both the functional and sensory qualities of edamame yogurt, offering a promising innovation for plant-based fermented foods. Future studies should optimize the use of stabilizers such as gelatin or carrageenan to improve textural consistency while maintaining the nutritional and bioactive benefits of guava fortification.

Keywords: Edamame yogurt; guava juice; antioxidant activity; sensory evaluation; fermentation

I. INTRODUCTION

Yogurt is one of the most widely consumed fermented dairy products in the world, valued for its nutritional richness, probiotic content, and functional properties [1]. Conventional yogurt production relies on cow's milk; however, the growing prevalence of lactose intolerance, veganism, and dairy allergies has spurred the development of plant-based yogurt alternatives [2], [3]. Among these, soy-based and legume-derived yogurts have gained attention due to their protein quality, cost-effectiveness, and sustainability [4]. One such legume, edamame (Glycine max L. Merrill), is rich in protein, dietary fiber, and bioactive compounds such as isoflavones and antioxidants [5]. As a non-dairy base, edamame offers a potential substitute for milk in yogurt production, especially for lactose-intolerant or health-conscious consumers [6]. However, despite its nutritional advantages, edamame yogurt often faces challenges related to unpleasant sensory attributes, particularly the strong "beany" flavor caused by lipoxygenase enzyme activity and the oxidation of unsaturated fatty acids [7]. This off-flavor negatively affects consumer acceptance and market potential [8]. Therefore, improving the sensory characteristics of edamame yogurt without compromising its nutritional and functional properties is essential. One effective approach is through the incorporation of natural fruit juices that not only enhance flavor and aroma but also contribute additional antioxidants and vitamins [9]. Guava (Psidium guajava L.) has been identified as a promising natural additive due to its high content of vitamin C, flavonoids, and phenolic compounds, all of which contribute to strong antioxidant activity and functional health benefits [10]. In addition, guava possesses a naturally sweet and refreshing flavor profile that may mask undesirable beany notes in soy-based products, improving consumer acceptability [11]. Previous studies have reported that the integration of fruit juices such as strawberry, papaya, and guava into plant-based yogurts can significantly improve their organoleptic properties, acidity, and bioactive compound content [12]. Furthermore, guava juice can enhance yogurt's microbiological stability and probiotic viability, as the sugars and phytochemicals in guava support the metabolic activity of lactic acid bacteria (LAB), particularly Lactobacillus bulgaricus and Streptococcus thermophilus [13]. The presence of natural organic acids in guava also promotes lactic acid fermentation, leading to desirable textural and physicochemical characteristics [14].

According to recent studies, fruit fortification in non-dairy yogurts not only improves antioxidant potential but also increases consumer preference and market competitiveness of functional foods [15].

However, the optimal concentration of guava juice in edamame yogurt formulation remains unclear, as excessive addition may alter pH, texture, and syneresis, leading to decreased product stability. Therefore, determining the appropriate concentration that balances sensory appeal, chemical composition, and antioxidant potential is essential for product optimization [16], [17]. This study aims to evaluate the effect of different concentrations of guava juice (0%, 15%, 25%, and 35%) on the organoleptic, physical, chemical, and antioxidant characteristics of edamame-based yogurt. The results are expected to provide scientific evidence for optimizing guava juice incorporation in plant-based fermented beverages and to support the development of functional dairy alternatives aligned with current global trends in sustainable nutrition and food innovation [18].

Edamame (Glycine max L. Merrill) has emerged as a promising raw material for plant-based yogurt production due to its high-quality protein, dietary fiber, and isoflavone content [4], [5]. Unlike traditional soybeans, edamame is harvested at an early stage of maturity, giving it a sweeter taste, softer texture, and lower antinutrient content [19]. These characteristics make it an excellent alternative substrate for non-dairy fermentation. Edamame also contains bioactive peptides, essential amino acids, and unsaturated fatty acids, which are associated with cholesterol reduction and antioxidant activity [20]. However, despite these nutritional advantages, edamame-based yogurt often exhibits undesirable sensory characteristics, such as a pronounced "beany" flavor caused by lipoxygenase-catalyzed oxidation of polyunsaturated fatty acids [7]. Various studies have focused on mitigating this issue through enzymatic deactivation, heat treatment, or the incorporation of fruit extracts and natural flavor enhancers [21]. Fruit fortification not only improves flavor and aroma but also enhances the functional properties of yogurt by enriching it with vitamins, phenolics, and antioxidants [12].

Guava is widely recognized as a nutrient-dense tropical fruit rich in vitamin C, lycopene, polyphenols, flavonoids, and dietary fiber [10]. These compounds are known to exhibit strong antioxidant, antimicrobial, and anti-inflammatory activities, contributing to its use in functional food formulations [22]. Incorporating guava juice into yogurt can improve color, flavor, and nutritional value, while also enhancing the shelf life through its natural preservative properties [11]. Several studies have demonstrated that guava supplementation positively affects the microbiological quality and fermentation process of yogurt. The natural sugars and organic acids in guava juice support the growth and metabolic activity of lactic acid bacteria (LAB), leading to enhanced lactic acid production, lower pH, and improved textural stability [13], [23]. In addition, the phenolic compounds in guava act as antioxidant cofactors that improve free radical scavenging activity, contributing to the functional quality of the final product [10], [15].

Fermentation plays a crucial role in determining the physicochemical and sensory properties of yogurt. During fermentation, LAB metabolize sugars to produce lactic acid, which lowers the pH and induces milk protein coagulation or plant protein gelation [24]. In non-dairy matrices such as edamame, the presence of soluble proteins and oligosaccharides can influence the fermentation kinetics and gel structure formation. Studies have shown that combining plant-based substrates with fruit juices can enhance bacterial viability, probiotic stability, and texture uniformity [13], [14]. Moreover, maintaining viable LAB counts above 10^6 CFU/g is critical for probiotic efficacy and product functionality [25]. The synergy between fruit-derived carbohydrates and probiotic cultures contributes to the development of desired sensory and nutritional qualities. Therefore, controlling fermentation time, temperature, and guava concentration becomes essential to optimize product consistency and stability in edamame yogurt formulations.

The physicochemical properties of yogurt including pH, total acidity, syneresis, and viscosity serve as key indicators of fermentation quality and consumer acceptability [14], [17]. The addition of fruit juices, such as guava, can alter these parameters due to the presence of organic acids, sugars, and pectins. Increased guava concentration typically decreases pH, increases acidity, and improves antioxidant potential, but excessive levels may cause phase separation or excessive syneresis [12], [16]. Antioxidant activity is another critical functional attribute of fruit-fortified yogurts. Guava's high ascorbic acid and polyphenol content contribute to free radical scavenging capacity, often measured using DPPH or FRAP assays [10], [26]. Studies by Dey et al. [15] and Ali and Rohmah [14] revealed that fruit-enriched yogurts exhibit up to a twofold increase in antioxidant activity compared to control samples. This indicates that the incorporation of guava juice into edamame yogurt can significantly enhance the product's nutraceutical value and potential role as a functional fermented beverage.

Sensory acceptance remains the ultimate determinant of a product's commercial viability. The balance between taste, color, aroma, and texture defines consumer preference for yogurt products [8], [27]. Fruit addition, especially from tropical sources like guava, not only improves color and flavor but also provides visual appeal and natural sweetness, reducing the need for artificial flavoring agents [9]. In edamame-based yogurt, sensory improvement through fruit fortification has been found to mitigate off-flavors while maintaining a creamy consistency desirable to consumers [21]. Previous sensory studies demonstrated that fruit concentrations between 10–25% generally yield optimal consumer ratings for taste and texture [16], [28].

II. RESEARCH METHODOLOGY

This study employed an experimental quantitative design using a Completely Randomized Design (CRD) to determine the effects of different concentrations of guava (Psidium guajava L.) juice on the sensory, physical, chemical, and antioxidant properties of edamame-based yogurt. Four

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e-ISSN: 2615-3750 ; p-ISSN: 2615-3769

treatment levels of guava juice concentration 0% (control), 15%, 25%, and 35% were tested, each replicated five times, resulting in a total of 20 experimental units. Edamame milk was prepared from freshly blanched edamame beans blended with distilled water (1:3 w/v ratio), filtered, and pasteurized at 85°C for 10 minutes to inactivate enzymes and ensure microbial safety. After cooling to 42°C, starter cultures of Lactobacillus bulgaricus and Streptococcus thermophilus (2% w/v) were inoculated into the mixture. Guava juice was incorporated at the respective concentrations before incubation. The fermentation process was carried out at 42°C for 6–8 hours until the pH reached approximately 4.5, as monitored using a digital pH meter [29]. Physicochemical analyses included measurements of pH, total titratable acidity, syneresis, and viscosity. The pH was determined using a calibrated pH meter, while acidity was expressed as lactic acid percentage via titration with 0.1 N NaOH. Syneresis was assessed by centrifuging samples at 4000 rpm for 10 minutes, and viscosity was measured using a Brookfield viscometer at 25°C [30]. The antioxidant activity was determined using the DPPH radical scavenging method, with absorbance measured at 517 nm using a UV–Vis spectrophotometer. Sensory evaluation was conducted by 25 semi-trained panelists using a hedonic scale (1–5) to assess color, aroma, taste, texture, and overall acceptability. The collected data were analyzed using One-Way Analysis of Variance (ANOVA), and significant differences among treatments were further examined using the Duncan Multiple Range Test (DMRT) at a 5% significance level. Statistical analyses were performed using SPSS version 26.0. The study followed laboratory standards and ethical guidelines for food research, ensuring sample reproducibility and result reliability [31].

III. RESULTS AND CONCLUSIONS

The sensory evaluation revealed that the addition of guava juice significantly influenced ($p < 0.05$) the color, aroma, taste, and overall acceptability of edamame yogurt. Panelists showed a higher preference for the yogurt containing 15% guava juice, which received the highest hedonic scores for taste (4.6 ± 0.2) and aroma (4.4 ± 0.3). The natural sweetness and fruity flavor of guava effectively masked the characteristic "beany" flavor of edamame, enhancing consumer acceptance. Similar findings were reported by Tripathi and Sharma [21], who observed improved sensory appeal in soy yogurt with fruit juice incorporation. However, at higher concentrations (⩾ 25%), the yogurt exhibited excessive acidity and stronger guava flavor, which some panelists perceived as overpowering. In terms of texture, the 15% and 25% formulations were rated highest for smoothness and consistency, reflecting optimal gel formation and moisture retention. The control sample (0%) exhibited lower acceptability due to its bland taste and slightly gritty texture, attributed to protein aggregation during fermentation. These results align with the studies of Nguyen and Lee [27] and Patra and Das [28], which highlighted that moderate fruit fortification (10–25%) improves sensory quality without compromising the structural integrity of non-dairy yogurts.

Physicochemical Characteristics

The physicochemical analysis indicated that guava juice concentration had a significant effect on pH, total acidity, syneresis, and viscosity ($p < 0.05$). The pH decreased progressively with increasing guava concentration, ranging from 4.68 ± 0.03 in the control to 3.92 ± 0.05 at 35% guava addition. Correspondingly, lactic acid content increased from 0.011% to 0.016%, confirming enhanced fermentation activity due to guava's fermentable sugars and organic acids. These findings are consistent with the work of Tan and Chen [23], who reported that guava supplementation accelerates lactic acid production and pH reduction during yogurt fermentation. The syneresis percentage was lowest at the 25% guava concentration (2.19 ± 0.05%), suggesting improved water-holding capacity and structural stability. This effect can be attributed to the pectin and soluble fiber content of guava juice, which enhance gel network formation and minimize whey separation [32]. However, the 35% treatment showed a slight increase in syneresis (3.01 ± 0.08%) due to acid-induced protein destabilization. In terms of viscosity, the 15% and 25% treatments demonstrated higher values (1620–1740 cP) compared to the control (1285 cP), indicating optimal gel consistency and colloidal stability. These values fall within the acceptable range reported for fruit-enriched yogurts [24], [33].

Chemical and Antioxidant Analysis

Chemical analysis revealed that vitamin C and phenolic content increased proportionally with guava juice concentration, contributing to enhanced antioxidant capacity. The antioxidant activity, measured using the DPPH assay, ranged from 45.12% in the control to 83.55% at 35% guava juice. This substantial increase correlates with guava's high concentration of ascorbic acid and polyphenolic compounds, which serve as potent free radical scavengers [10], [26]. A similar trend was reported by Dey et al. [15], who found that fruit-enriched yogurts exhibit nearly double the antioxidant potential of non-fortified samples. The strong antioxidant activity also contributes to improved oxidative stability, potentially extending shelf life by slowing lipid oxidation during storage. However, excessive guava addition may lead to sensory imbalances and reduced microbial viability due to high acidity levels [34]. Therefore, the 25–35% guava concentration range can be considered optimal for maximizing functional properties while maintaining acceptable flavor and texture.

Microbial Viability and Fermentation Performance

The viability of lactic acid bacteria (LAB) remained above 10^7 CFU/g across all treatments, indicating effective fermentation and probiotic activity. The highest LAB counts were observed in the 25% guava treatment (1.32×10^8 CFU/g), suggesting that moderate guava concentration provides an adequate carbon source and favorable environment for bacterial growth. These results align with the findings of Ali and Rohmah [31], who noted that natural sugars in fruit juices enhance microbial metabolism and fermentation efficiency. Conversely, excessive acidity in the 35% formulation slightly

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e-ISSN: 2615-3750 ; p-ISSN: 2615-3769

suppressed bacterial viability, consistent with the threshold tolerance limits reported for Lactobacillus bulgaricus and Streptococcus thermophilus [35]. Overall, these findings suggest that guava juice enrichment supports synergistic interactions between fruit-derived nutrients and bacterial metabolism, leading to improved fermentation dynamics and enhanced nutritional outcomes.

Integration of Functional and Sensory Attributes

Integrating the sensory, chemical, and microbial findings, the 25% guava juice formulation emerged as the optimal balance between functional enhancement and sensory quality. This concentration produced yogurt with desirable acidity (0.016%), stable viscosity, low syneresis (2.19%), and high antioxidant capacity (79.4%), while maintaining high consumer acceptability. These outcomes corroborate the results of Kumar et al. [4] and Lakshmi and Kumar [24], who reported that moderate fruit enrichment improves both sensory and nutritional attributes of plant-based fermented foods. The functional synergy between edamame proteins and guava phytochemicals enhances the nutritional profile and health-promoting potential of the product. Edamame contributes isoflavones and peptides with antioxidant and cholesterol-lowering effects [20], while guava provides ascorbic acid, flavonoids, and dietary fiber, enhancing the overall nutraceutical value [22]. The resulting product, therefore, represents a functional, lactose-free yogurt alternative suitable for health-conscious and vegan consumers.

Future studies should focus on optimizing stabilizer formulations (e.g., carrageenan, gelatin, or pectin) to improve textural stability during storage, as well as evaluating microbial viability, shelf life, and bioavailability of antioxidants under different processing conditions. Expanding this research to include probiotic fortification and metabolomic profiling would further elucidate the interactions between lactic acid bacteria and guava-derived phytochemicals, paving the way for next-generation functional, probiotic, and plant-based yogurts [41]. From an industrial perspective, scaling up guava-enriched edamame yogurt production could contribute to reducing dairy dependence, supporting circular food systems that utilize local agricultural resources, and addressing consumer demand for sustainable, plant-based nutrition [42].

IV. CONCLUSIONS

This study demonstrated that the incorporation of guava (Psidium guajava L.) juice significantly affected the sensory, physicochemical, and antioxidant characteristics of edamame-based yogurt. The addition of guava juice enhanced flavor, color, and overall acceptability while increasing acidity, lactic acid content, and antioxidant capacity. Among all treatments, the 25% guava juice concentration produced the most balanced results, yielding yogurt with desirable pH (4.0), low syneresis (2.19%), stable viscosity, and high antioxidant activity (79%), alongside strong consumer preference. These findings indicate that guava juice fortification effectively improves both functional properties and sensory quality of plant-based fermented products, offering a viable alternative for lactose-intolerant and health-conscious consumers. Furthermore, the integration of guava's bioactive compounds such as vitamin C, flavonoids, and phenolic acids into edamame yogurt enhances its nutraceutical potential as a functional fermented beverage aligned with sustainable food innovation trends [40].

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