

Research Article

Development of Mackerel (*Rastrelliger* sp.) Turbin Quiche Fortified with Tofu and Red Beans (*Phaseolus vulgaris* L.): Sensory Acceptability and Nutritional Profile as a Healthy Snack Alternative for Adolescents

Bagaskara Agung Putra Wicaksono¹, Esteria Priyanti^{2,*}

¹ Culinary Arts Study Program, Ibu Kartini Academy of Social Welfare; e-mail : esteria@aksibukartini.ac.id

² Culinary Arts Study Program, Ibu Kartini Academy of Social Welfare; e-mail : esteria@aksibukartini.ac.id

* Corresponding Author: esteria@aksibukartini.ac.id

Abstract: This study aims to determine adolescents' acceptance of mackerel turbin quiche, identify the best formulation of the product, and analyze its nutritional content. This study used an experimental method. The results showed that the mackerel turbin quiche product that was well accepted by adolescents was F1, which used 250g of mackerel, 125g of tofu, and 375g of red beans. The best formulation of mackerel turbin quiche used ingredients divided into three (3) parts: crust, filling, and custard. The quiche crust consisted of 500g wheat flour, 300g margarine, 135g powdered sugar, 15g powdered milk, and 2 egg yolks. The filling consisted of 250g mackerel, 375g red beans, 125g tofu, and 100g onion. The custard consisted of 1000 ml UHT milk, 10 egg yolks, 6g salt, 3g ground pepper, and 3g ground nutmeg. Each 45g serving of mackerel turbin quiche contained 194.34 Kcal of energy, 21.60g carbohydrates, 10.09g fat, and 5.69g protein. It can be concluded that mackerel turbin quiche can be used as a healthy snack alternative for adolescents.

Keywords: Adolescent Acceptance; Experimental Method; Mackerel Turbin Quiche; Nutritional Content; Product Formulation.

1. Introduction

A healthy lifestyle is identical with activities that maintain physical, mental, and emotional balance. A healthy lifestyle can begin with regular exercise, sufficient sleep, health check-ups, and good dietary patterns. The principle of a healthy diet is closely related to balanced nutrition. A diet with balanced nutrition must pay attention to food intake on one plate of dish according to daily nutritional needs. The principle of a healthy diet can be initiated since adolescence so that in adulthood one is prevented from diseases caused by poor dietary patterns [1].

Adolescence is a very vulnerable age because there is a rapid process of growth and development. When the process of growth and development occurs, the need for nutrients will increase. Adolescents who receive good nutritional intake tend to have optimal growth and development, as well as good focus in learning and academic performance [2]. Many factors influence the nutritional intake of adolescents, one of which is the habit of consuming snacks. Adolescents like to consume certain snacks without paying attention to nutritional content [3]. In fact, healthy snacks should be able to contribute 36% of energy, 29% of protein, and 59% of iron [4].

Adolescents need to be introduced to healthy and nutrient-dense snacks. Quiche can be one of the snack options to be introduced to adolescents. In general, quiche is known by the public as a pie with savory taste, as it uses fillings such as smoked beef or sausage, spinach, mushrooms, cheese, and custard. The development of quiche products in Indonesia is still rarely carried out. This is supported by the limited number of research results discussing quiche products. In recent years, published research on quiche products includes tempeh

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quiche as an alternative savory open tart with Indonesian taste [5], tilapia-substituted quiche lorraine for the millennial era [6], and turubuk quiche [7].

The lack of research regarding quiche product development has led the Author to be interested in developing a quiche product using local food ingredients. To create variations in quiche dishes, the filling of quiche can be modified by substituting the main ingredients with local food ingredients. Mackerel (*Rastrelliger* sp.) can be used as a substitute for smoked beef or sausage. Meanwhile, tofu and red beans (*Phaseolus vulgaris* L.) can be used as substitutes for spinach and mushrooms. These three ingredients are local food items that are easy to obtain.

Mackerel is also known as ikan kembung. This type of fish is a good source of animal protein for body health. Mackerel is easy to find at a relatively affordable price, so it is widely used in everyday family meals [8]. Tofu and red beans are known as sources of plant-based protein that are easy to obtain and process into various dishes. Tofu has many benefits, including helping to lower cholesterol levels, maintaining brain function, and preventing osteoporosis [9]. Meanwhile, red beans are rich in nutrients that help keep blood sugar levels stable, improve heart health, and serve as a source of energy.

Based on the background explanation, we carried out a product innovation called "mackerel turbin (tofu and red bean) quiche." The objectives of this study are to determine adolescent acceptance of mackerel turbin quiche, to identify the best formula of mackerel turbin quiche product, and to determine the nutritional content of the mackerel turbin quiche product.

2. Preliminaries or Related Work or Literature Review

The nutritional needs of adolescents are disproportionately high relative to other age groups due to the rapid physiological growth and developmental changes that characterize this life stage. Rapid growth and development during adolescence increase caloric needs, making this a period when both dietary excesses and deficiencies are particularly common. Despite these heightened nutritional requirements, adolescents frequently make food choices that are inconsistent with dietary guidelines. Studies have found that smaller, more frequent, and less energy-dense snacks are associated with higher overall diet quality in adolescents, yet the reality of adolescent snacking behavior often skews toward nutrient-poor, energy-dense processed foods. Research indicates that adolescents consume roughly one-third of their total daily energy intake from snacks, underscoring the critical importance of improving the nutritional quality of snack products available to this demographic. This reality presents a clear opportunity for the development of innovative, nutrient-dense snack products that are simultaneously appealing and health-promoting for adolescents, which forms the primary motivation for the present study [1].

Quiche, as a savory pastry product, offers a versatile culinary platform for the incorporation of diverse local food ingredients with high nutritional value. Previous studies on quiche product development in the Indonesian context have been limited, with documented research including tempeh quiche as an alternative savory open tart [5], tilapia-substituted quiche lorraine targeting the millennial demographic [6], and turubuk quiche as an effort to promote local food [7]. These prior works have explored plant-based and fish-based substitutions as filling components, yet none has examined the combined use of mackerel, tofu, and red beans as a complementary protein trifecta within a quiche formulation designed specifically for adolescents. The present study addresses this gap by developing a mackerel turbin quiche, a product specifically formulated with mackerel (*Rastrelliger* sp.), tofu, and red beans to optimize its sensory profile and nutritional contribution as a healthy snack for the adolescent population.

Mackerel (*Rastrelliger* sp.) serves as the primary animal protein component in this study's formulation. The protein content of Indian mackerel (*Rastrelliger kanagurta*) has been reported at approximately 21.6% on a wet weight basis, with polyunsaturated fatty acids comprising 37.4% of its total fatty acid composition, of which 87.9% are omega-3 fatty acids. The nutritional significance of mackerel extends beyond its protein content; its omega-3 fatty acid profile (particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)) is associated with cardiovascular protection, improved cognitive function, and anti-inflammatory effects. Mackerel is furthermore widely available throughout Indonesian coastal regions at an accessible price point, making it a practical and contextually appropriate ingredient for the development of local functional food products for adolescents. Yusuf & Naitu, (2024) confirmed that mackerel is broadly consumed in Indonesian household meals

due to its affordability and availability, further supporting its suitability as a primary ingredient in the present formulation.

Tofu and red kidney beans (*Phaseolus vulgaris* L.) constitute the plant-based protein sources in this study's formulation, providing complementary nutritional profiles that enhance the overall protein quality and micronutrient density of the product. Red kidney beans are high in protein content ranging from 15–30%, crude fiber of approximately 21.9%, complex carbohydrates of 50–60%, and dietary fiber of 15–20%, and contain appreciable levels of minerals including iron (8.2 mg), calcium (143 mg), and phosphorus (407 mg) [10]. Tofu, derived from soybeans (*Glycine max* L.), is recognized as one of the most complete plant-based protein sources, containing all nine essential amino acids, with studies reporting protein content of approximately 10g per 100g serving alongside significant quantities of calcium, iron, magnesium, and isoflavones [11]. The combination of mackerel, tofu, and red beans in a single quiche formulation represents a strategic nutritional design: animal protein from mackerel complements plant proteins from tofu and red beans through amino acid complementarity, while the high fiber content of red beans supports satiety and glycemic regulation [12].

3. Proposed Method

This study used an experimental method aimed at determining the best formula of mackerel turbin quiche. The study began with a formula optimization stage. At this stage, the production of mackerel turbin quiche was carried out in small quantities and in a short amount of time. The purpose was to determine the appropriate quantities of mackerel, tofu, and red beans to be used in the subsequent experiments. From the results of the formula optimization, it was found that the ideal amount of mackerel for this study was 250g, while the amount of tofu and red beans was formulated based on a total weight of 500g. The formulations of tofu and red beans used were: 25% tofu and 75% red beans for product F1, 50% tofu and 50% red beans for product F2, and 75% tofu and 25% red beans for product F3. The mackerel turbin quiche experiment was conducted with three repetitions.

The ingredients used in this study were divided into three parts: crust, filling, and custard. The quiche crust used wheat flour, margarine, powdered sugar, powdered milk, and egg yolks. The quiche filling used mackerel, red beans, tofu, and onion. The quiche custard used UHT milk, egg yolks, salt, ground pepper, and ground nutmeg. The types of equipment used in this study included a digital scale, stainless steel bowl, spatula, balloon whisk, measuring jug, mixer, rolling pin, quiche mold, and oven.

This study also conducted sensory evaluation through observation and scoring of taste, aroma, texture, and color to obtain product characteristics that meet the desired criteria. The sensory evaluation conducted in this study consisted of descriptive testing, hedonic testing, and ranking testing. The purpose of the descriptive test was to provide descriptive assessment of the taste, aroma, texture, and color of the mackerel turbin quiche, which served as the basis for deciding whether further experimentation was needed. The hedonic test was carried out after a series of repeated experiments successfully produced mackerel turbin quiche products that met the criteria. In the hedonic test, 35 untrained panelists were involved. The panelists gave preference scores for the taste, aroma, texture, and color of the three mackerel turbin quiche products. The questionnaire used in the hedonic test employed a 5-point hedonic scale. The ranking test was conducted after the panelists completed the hedonic test. Panelists were asked to rank the products based on which one they considered the best. This ranking test served to determine the conclusion of which mackerel turbin quiche product was the best.

4. Results and Discussion

This study produced three (3) mackerel turbin quiche products that had sensory characteristics which were not significantly different. Images of the three products can be seen in Figure 1, Figure 2, and Figure 3.



Figure 1. Image from Left to Right of Product Results from F1, F2, F3 Mackerel Turbin Quiche Top View



Figure 2. Image from Left to Right of Product Results from F1, F2, F3 Mackerel Turbin Quiche Side View



Figure 3. Image from Left to Right of Product Results from F1, F2, F3 Mackerel Turbin Quiche When Cut

The hedonic test of the mackerel turbin quiche products was carried out with the help of 35 untrained panelists. The panelists were adolescents from SMK Ibu Kartini and adolescents living near the author's residence. Respondents provided preference ratings on the sensory characteristics of the mackerel turbin quiche products. The sensory characteristics evaluated were taste, aroma, texture, and color.

The results of the hedonic test for the taste, aroma, texture, and color of the three mackerel turbin quiche formulas can be seen in Table 1.

Table 1. Hedonic Test Data Analysis of Mackerel Turbin Quiche

Formula	Taste	Aroma	Texture	Color
F1	3.57 ± 0.92	3.43 ± 0.95	3.49 ± 0.74	3.63 ± 0.60
F2	3.04 ± 1.24	3.54 ± 0.92	3.46 ± 0.74	3.60 ± 0.65
F3	3.09 ± 1.12	3.51 ± 0.98	3.20 ± 0.93	3.43 ± 0.61

Based on Table 1, the results of the hedonic test showed that panelists preferred the taste of mackerel turbin quiche F1, which contained a smaller amount of tofu and a larger amount of red beans. This was shown by the mean score obtained, which was 3.57.

Respondents chose product F1 with the composition of 250g mackerel, 125g tofu, and 375g red beans.

Based on Table 1, it is concluded that the hedonic test for aroma on mackerel turbin quiche showed the most preferred average score was for product F2, with a mean score of 3.54. Respondents selected product F2 with the content of 250g mackerel, 250g tofu, and 250g red beans, resulting in a balanced aroma due to the equal proportion of the three ingredients.

Based on Table 1, it can be concluded that the hedonic test for texture on mackerel turbin quiche showed the most preferred average score was for product F1, with a mean score of 3.49. Respondents selected product F1 with the composition of 250g mackerel, 125g tofu, and 375g red beans, resulting in an acceptable texture due to the high amount of red beans.

Based on Table 1, it can be concluded that the hedonic test for color on mackerel turbin quiche showed the most preferred average score was for product F1, with a mean score of 3.63. Respondents selected product F1 with the content of 250g mackerel, 125g tofu, and 375g red beans, resulting in an attractive color that stimulated appetite.

Based on the analysis of the ranking test results, the most preferred mackerel turbin quiche product by the respondents was product F1, which used 250g mackerel, 125g tofu, and 375g red beans. Thus, this mackerel turbin quiche product can be used as an innovative healthy snack for adolescents.

The results of the hedonic and ranking tests showed that the best formula of the mackerel turbin quiche product was F1. The composition of ingredients used in product F1 was grouped into three (3) parts, namely the crust, filling, and custard. The quiche crust used: 500g wheat flour, 300g margarine, 135g powdered sugar, 15g powdered milk, and 2 egg yolks. The quiche filling used: 450g mackerel, 375g red beans, 125g tofu, and 100g onion (Bombay onion). The quiche custard used: 1000 ml UHT milk, 10 egg yolks, 6g salt, 3g ground pepper, and 3g ground nutmeg.

The energy, protein, fat, and carbohydrate content of the best mackerel turbin quiche product was calculated using data from the Indonesian Food Composition Table 2017. The calculated nutritional content of one (1) full recipe of mackerel turbin quiche is shown in Table 2. Meanwhile, the calculated nutritional analysis per serving of mackerel turbin quiche is presented in Table 3.

Table 2. Nutritional Content of Mackerel Turbin Quiche for One (1) Recipe

Food Ingredient (Unit)	Weight (g)	Energy (Kcal)	Protein (g)	Total Fat (g)	Carbohydrate (g)
Margarine (g)	300	2160.0	1.8	243.0	1.2
Powdered sugar (g)	135	525.2	0.0	0.1	134.5
Egg yolk (unit)	2	6.7	0.3	0.2	0.0
Powdered milk (g)	15	77.0	3.7	4.5	5.4
Wheat flour (g)	500	1665.0	45.0	5.0	386.0
Mackerel (g)	250	250.0	42.6	6.8	4.4
Tofu (g)	125	100.0	13.6	5.9	1.0
Red beans (g)	375	641.3	41.3	8.3	105.0
Butter	20	148.4	0.1	16.3	0.3
UHT Milk (ml)	1000	600.0	32.0	32.0	48.0
Egg yolk (g)	10	33.5	1.6	1.1	0.1
Pepper (g)	3	10	0	0	2
Nutmeg (g)	3	2.4	0.0	0.2	0.2
Salt (g)	6	0	0	0	0
Total	-	6219	182	323	688

Table 3. Nutritional Content of Mackerel Turbin Quiche per Serving

Nutrient	One recipe	32 Servings	RDA	One Serving (45g)	DV
Carbohydrate (g)	688.0	21.50	7%	21.50	325
Fat (g)	323.0	10.09	15%	10.09	67
Protein (g)	182.0	5.69	9%	5.69	60
Energy (Kcal)	6219.0	194.34	9%	194.34	2150

The mackerel turbin quiche product has a serving size of 45g per piece. Based on this portion size, the Recommended Dietary Allowance (RDA) for the mackerel turbin quiche can be calculated. The calculation of these RDA values refers to Daily Value for the general group category (Food and Drug Supervisory Agency of the Republic of Indonesia, 2016). From the calculation results, it is known that per serving, the mackerel turbin quiche contains 194.34 Kcal of energy, 21.60g of carbohydrates, 10.09g of fat, and 5.69g of protein. Therefore, if adolescents consume 45g of mackerel turbin quiche, it can fulfill 9% of energy needs, 9% of protein needs, 15% of fat needs, and 7% of carbohydrate needs.

5. Comparison

The hedonic test results demonstrated that F1, comprising 250g mackerel, 125g tofu, and 375g red beans, achieved the highest overall acceptability among the three formulations tested across taste (3.57), texture (3.49), and color (3.63) attributes, while F2 obtained the highest aroma score (3.54). The superior taste performance of F1 is consistent with established understanding of flavor chemistry in mackerel-based products. Mackerel contains substantial concentrations of free amino acids, organic acids, and nucleotides that collectively contribute a complex umami flavor profile, with total equivalent umami concentration reported at elevated levels compared to many other fish species [14]. In F1, the higher proportion of red beans (375g) relative to tofu (125g) produced a flavor synergy that complemented rather than masked the characteristic umami notes of mackerel, yielding a more harmonious and palatable taste profile. In contrast, F3 with the highest tofu proportion (375g) may have diluted the characteristic savory taste of mackerel with the milder, bean-curd flavor of tofu, explaining its lower taste score (3.09). These findings align with the principle in sensory food science that flavor balance in multi-component protein formulations is critically dependent on the relative proportions of each ingredient and the degree to which their flavor profiles interact constructively [15] [16].

The texture acceptability results, in which F1 achieved the highest mean score (3.49) compared to F2 (3.46) and F3 (3.20), can be attributed to the structural contribution of red beans as the dominant filling component in F1. Red kidney beans (*Phaseolus vulgaris* L.) contain a high proportion of slow digestible starch (SDS) and resistant starch (RS), which contributes to a characteristic firm yet pleasant mouthfeel that consumers find appealing in savory pastry products [17]. The lower texture score of F3 is likely attributable to the dominance of tofu (375g), whose softer, gel-like texture may have created a filling that is perceptually too soft and lacking in textural contrast within the quiche structure. To enhance flavor, texture, and overall acceptance of legume-based food products, appropriate balancing of legume components with complementary ingredients plays a critical role in determining marketability and consumer acceptance. This principle was evident in the present study, where the proportion of red beans functioned as a textural determinant that significantly influenced panelist preference [18].

The color acceptability pattern, with F1 scoring highest (3.63) and F3 lowest (3.43), reflects the visual impact of ingredient proportion on the final baked product appearance. The combination of mackerel's characteristic flesh color, the deep red pigmentation of kidney beans and the pale cream tone of tofu creates a visually appealing contrast when baked. In F1, the dominant proportion of red beans generated a color profile perceived as visually stimulating and appetite-inducing by adolescent panelists. Sensory analysis has evolved into one of the most important methodologies for food innovation and ensuring final product acceptance by consumers, with visual attributes such as color frequently serving as the initial driver of consumer preference before taste is evaluated [19]. The aroma advantage of F2 (3.54) over F1 (3.43) can be attributed to the equal distribution of mackerel, tofu, and red beans in F2, which produced a more balanced aromatic profile without any single ingredient's

volatile compounds dominating, consistent with research demonstrating that balanced ingredient proportions tend to generate more harmonious aroma profiles in mixed-protein food formulations [20].

The nutritional profile of the best-formula mackerel turbin quiche (F1) warrants comparison with existing quiche and savory snack products reported in the literature. Each 45g serving of F1 provided 194.34 kcal, 5.69g protein, 10.09g fat, and 21.60g carbohydrates, fulfilling 9% of daily energy, 9% of protein, 15% of fat, and 7% of carbohydrate needs based on BPOM Republic of Indonesia reference values (2,150 kcal). Conventional quiche and pastry products are typically characterized by high saturated fat content from butter or cream-based custard, a nutritional profile that poses challenges for health-conscious reformulation in the context of modern dietary guidance linking high saturated fat intake with elevated cardiovascular risk [21]. The present formulation's use of mackerel as the primary protein source alongside tofu and red beans represents a meaningful improvement over conventional quiche formulations dominated by processed meats, as it shifts the fat profile toward a more favorable polyunsaturated-to-saturated fatty acid ratio while simultaneously increasing protein and fiber density. This reformulation strategy is consistent with current food technology trends emphasizing the replacement of animal-derived high-fat ingredients with locally sourced, nutrient-dense alternatives in savory baked goods [22].

The present study offers a distinctive contribution to the quiche product development literature in the Indonesian context. While prior research has explored tilapia-substituted quiche lorraine [6] and tempeh quiche as a local-flavored alternative [5], neither study incorporated a complementary dual plant-protein system alongside the fish component, nor was the product specifically designed and evaluated for the adolescent demographic. The hedonic test is among the most widely used methods for measuring consumers' level of liking of food products, and its combined application with a ranking test provides a robust multi-criteria framework for identifying optimal formulations in food product development research. The tri-component protein design of the present study demonstrates that locally available, affordable ingredients can be strategically combined to produce a snack product with a nutritionally enriched profile and strong adolescent acceptability. Future research should extend this work by incorporating a proximate analysis for fiber, saturated fat, and micronutrient content, as well as by expanding the panelist population to include a broader adolescent demographic across different socioeconomic backgrounds to strengthen the generalizability of the sensory findings

6. Conclusions

This research, titled A Study on the Development of Mackerel Turbin Quiche (Mackerel Quiche with the Addition of Tofu and Red Beans) as a Healthy Snack Alternative for Adolescents, led to the following conclusions: (1) The mackerel turbin quiche product that was well accepted by adolescents was F1, using 250g of mackerel, 125g of tofu, and 375g of red beans. (2) The best formula for mackerel turbin quiche used ingredients grouped into three (3) parts: crust, filling, and custard. The quiche crust consisted of 500g wheat flour, 300g margarine, 135g powdered sugar, 15g powdered milk, and 2 egg yolks. The filling consisted of 250g mackerel, 375g red beans, 125g tofu, and 100g onion. The custard consisted of 1000 ml UHT milk, 10 egg yolks, 6g salt, 3g ground pepper, and 3g ground nutmeg. (3) One (1) serving of mackerel turbin quiche weighing 45g contains 194.34 Kcal of energy, 21.60g of carbohydrates, 10.09g of fat, and 5.69g of protein.

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