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Differences in Nutritional Value of Rice Crackers with the Addition of Three Types of Leaves (Moringa, Torbangun, and Katuk)

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A B S T R A C T

Rice crackers are a popular snack made from rice flour, typically characterized by a moisture content of less than 3%. The incorporation of moringa, torbangun, and katuk leaves in their formulation is based on their high iron content, which can help reduce iron deficiency. Additionally, xanthan gum is added to enhance the texture of the final product. This study aimed to evaluate the effects of different leaf types and xanthan gum concentrations on the nutritional properties of rice crackers. A factorial Completely Randomized Design (CRD) was employed, with two factors and two replications. Factor I was the type of leaf (moringa, torbangun, and katuk), while Factor II was the xanthan gum concentration (0.5%, 1%, and 1.5%). Data were analyzed using Analysis of Variance (ANOVA) at a 5% significance level, and significant interactions were further examined using Duncan's Multiple Range Test (DMRT) at 5%. The results indicated that the type of leaf and xanthan gum concentration had a significant effect ($P<0.01$) on moisture, ash, fat, protein, and carbohydrate content. The highest moisture (2.93%), ash (3.12%), and protein (1.29%) contents were observed in rice crackers containing moringa leaf and 1.5% xanthan gum. The highest fat content (6.10%) was found in moringa leaf rice crackers with 0.5% xanthan gum, while the highest carbohydrate content (82.55%) was recorded in torbangun leaf rice crackers with 1% xanthan gum. These findings highlight the potential of incorporating iron-rich leaves and xanthan gum to improve the nutritional quality and textural properties of rice crackers.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 3: Good Health and Well-Being
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production
SDG 13: Climate Action

1. INTRODUCTION

1.1. Research Background

Rice crackers are a traditional Japanese snack made from rice flour or glutinous rice, characterized by a crispy texture and a savory, salty taste [1]. Natural ingredients rich in iron, such as katuk leaves (*Sauropus androgynus*), torbangun leaves (*Coleus amboinicus*), and moringa leaves (*Moringa oleifera*), can serve as viable solutions to increase daily iron intake in the community.

Moringa (Moringa oleifera) is a tropical plant widely found in Indonesia. Every 100 grams of moringa leaves contain 6 mg of iron. Additionally, moringa leaves provide 92 calories of energy,

75.5 g of water, 5.1 g of protein, 1.6 g of fat, 14.3 g of carbohydrates, 8.2 g of fiber, 1077 mg of calcium, 76 mg of phosphorus, 61 mg of sodium, 298 mg of potassium, 0.1 mg of copper, and 0.6 mg of zinc [2]. They also contain 220 mg of vitamin C, 0.8 mg of niacin, 0.05 mg of riboflavin, 0.06 mg of thiamine, and 6.78 mg of vitamin A [3], along with antioxidants such as ascorbic acid, flavonoids, phenolics, and carotenoids [4]. Other plants that can enhance the iron content in rice crackers include torbangun and katuk leaves. Every 100 grams of torbangun leaves contain 13.6 mg of iron, 27 kcal of energy, 1.3 g of protein, 0.6 g of fat, 4 g of carbohydrates, 5.1 mg of vitamin C, and 0.16 mg of vitamin B1 [5]. Meanwhile, every 100 grams of fresh katuk leaves contain 3.5 mg of iron, 6.4 g of protein, 1 g of fat, 9.9 g of carbohydrates, 1.5 g of fiber, 233 mg of calcium, and 9152 mcg of beta-carotene [6].

The production of rice crackers using glutinous rice flour combined with moringa, katuk, and torbangun leaves, which are high in fiber, may affect the characteristics of the final product. The addition of hydrocolloids can substitute for gluten's role [7]. Xanthan gum is used in cracker production to create a matrix capable of trapping gas bubbles within the dough, allowing the dough to expand properly and achieve high elasticity. Additionally, xanthan gum acts as an emulsifier in the cracker dough. Its molecules form inter-molecular aggregates through hydrogen bonding and polymer adhesion [8]. Based on the above explanation, this study involves the production of rice crackers using different types of leaves (moringa, torbangun, and katuk) and the addition of xanthan gum as an iron-rich snack.

2. MATERIALS AND METHODS

This research was carried out in September–December 2024 in the Food Processing Technology Laboratory, Food Analysis Laboratory, and Sensory Testing Laboratory of the Food Technology Study Program at UPN "Veteran" East Java.

2.1. Materials

The materials used in this study consisted of raw materials and analytical materials. The raw materials for rice crackers production included moringa leaves, torbangun leaves, and katuk leaves, which were sourced from Krian District, Sidoarjo Regency, as well as white glutinous rice flour (Rose Brand), sugar (Gulaku), salt (Daun), maltodextrin (DE 15-20), xanthan gum (Fufeng), soy protein isolate (Linyi), baking powder (Koepoe-Koepoe), water, and vegetable oil (Bimoli). Materials used for analysis included benzene (Merck), H_2SO_4 solution (Merck), methanol (Merck), ethanol (Merck), K_2SO_4 solution (Merck), distilled water, NaOH (Merck), gallic acid (Merck), Folin-Ciocalteu reagent (Merck), DPPH (Sigma), Na_2CO_3 (Merck), and β-carotene (Sigma).

2.2. Methods

The preparation of fresh moringa, torbangun, and katuk leaves began with harvesting them on the same day as the rice crackers production. The freshly harvested leaves were separated from their stems and weighed (20 grams per type of leaf). The leaves were then washed under running water and blanched for **7** seconds**.** After blanching, the fresh leaves were finely chopped using a blender to produce minced fresh leaves.

The mixing process began by combining 100% glutinous rice flour, 2% baking powder, and 1% salt until evenly distributed. In the second stage, 14% oil, 78% water, 0.5% maltodextrin, 8% sugar, 15% soy protein isolate, and xanthan gum (according to the treatment) were mixed for 10 minutes. The first and second mixtures were then combined until homogeneous, forming a dough. Next, 20 grams of leaves (depending on the treatment) were added to the dough and mixed until well incorporated. The rice crackers dough was then subjected to a resting stage for 30 minutes before being rolled out with a rolling pin to a thickness of 2 mm and shaped. The shaped rice crackers were placed on a baking tray lined with baking paper** and baked at 170ºC for 20 minutes.

This study employed a Completely Randomized Design (CRD) with a factorial pattern consisting of two factors, where each treatment was replicated twice. The first factor was the addition of three types of leaves: Moringa leaves (A1), torbangun leaves (A2), and katuk leaves (A3). The second factor was the addition of Xanthan Gum (XG) at 0.5% (B1), 1% (B2), and 1.5% (B3).The collected data were analyzed using Analysis of Variance (ANOVA), and if significant differences were found among treatments, further analysis was conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level

3. RESULT AND DISCUSSION

3.1. Moisture content

Table 1 shows that the moisture content of rice crackers varies depending on the type of leaf added. Rice crackers with moringa leaves had the highest moisture content **(**2.70%–2.93%**)**, followed by those with katuk leaves **(**1.68%–2.62%**)** and torbangun leaves **(**0.92%–1.55%**).** This is due to the fiber content in the leaves, which can bind water. Differences in fiber content among raw materials affect the product's ability to absorb water. The fiber content of moringa leaves is 8.2 g/100 g, katuk leaves 1.5 g/100 g [2], and torbangun leaves 1 g/100 g [9]. According to Ref. [10], fiber consists of **insoluble fiber components such as cellulose,** which is made up of long chains of glucose molecules with multiple hydroxyl (-OH) groups. These groups are **hydrophilic**, allowing them to attract and bind water molecules. A higher fiber content in raw materials can trap water more effectively, making it more difficult for water to evaporate, resulting in a higher moisture content in the final product [11].

Table 1. The physical analysis results of rice crackers

Treatment		Moisture (%)	Ash (%)
Types of Leaves	Xanthan Gum		
Moringa	0.5%	2.70	2.84
	1.0%	2.82	3.05
	1.5%	2.93	3.12
Torbangun	0.5%	0.92	1.91
	1.0%	1.18	2.00
	1.5%	1.55	2.06
Katuk	0.5%	1.68	2.23
	1.0%	2.18	2.50
	1.5%	2.62	2.65

The addition of xanthan gum can also increase the moisture content of rice crackers. This increase is influenced by its ability

to form a gel. Hydrocolloids contribute to increasing the overall moisture content in baked goods. Their high water-holding capacity allows for greater moisture retention in the final product [12]. The addition of 2% xanthan gum in gluten-free biscuits can increase moisture content by 6.16%–9.22%**,** compared to the control treatment with a moisture content of 5.41% [13]**.**

3.2. Ash Contents

Table 1 shows that the ash content of rice crackers can be influenced by differences in the ash content of the leaves. Rice crackers made with moringa leaves had the highest ash content (2.84%–3.12%). followed by those with katuk leaves (2.23%–2.65%) and torbangun leaves (1.91%–2.06%). Moringa leaves contain 3.5 g/100 g. katuk leaves 1.7 g/100 g [2], and torbangun leaves 1.6 g/100 g [9]. A higher ash content in the leaves results in a higher ash content in the final product. The addition of katuk leaf flour at concentrations of 2%, 3%, and 4% in biscuits can increase the ash content to 0.99%, 1.53%, and 2,17% [14].

The ash content in rice crackers can also be influenced by the fiber content of the added leaves. Moringa leaves contain 8.2% fiber, which is higher than katuk leaves (1.5%) [2] and torbangun leaves (1%) [9]. Fiber is composed of cell wall components that contain organic ions such as silicon, calcium, and magnesium. Fiber also plays a role in binding minerals and electrolytes within the glucuronic acid structure of hemicellulose [14].

The addition of xanthan gum can also increase the ash content of rice crackers. This is due to the ash content present in xanthan gum.. Xanthan gum contains 4.2% ash [15]. The higher the amount of xanthan gum added, the greater the ash content in the product. Cookies with 2%, 3%, and 4% xanthan gum contain ash levels of 0.86%, 0.89%, and 0.91% [16].

3.3. Fat Contents

Table 2 shows that the fat content of rice crackers is influenced by the type of leaf used. Rice crackers with moringa leaves had the highest fat content **(**4.5%–6.10%**).** followed by those with katuk leaves **(**4.08%–5.23%**)** and torbangun leaves **(**3.51%– 4.26%**).** The differences in fat content are due to the varying fat levels in the leaves used. A higher fat content in the raw materials results in a higher fat content in the final rice crackers. The fat content of moringa leaves is 1.6 g/100 g. katuk leaves 1 g/100 g. and torbangun leaves 0.6 g/100 g [5] [9]. The addition of 2%. 2.5%. and 3% moringa leaves corresponded to fat content increases of 3.34%. 3.40%. and 3.61% [1].

The addition of xanthan gum can also reduce the fat content of rice crackers. This is due to xanthan gum's ability as a hydrocolloid to reduce the oil absorption index in the dough, resulting in a lower fat content in the final product. Hydrocolloid can reduce the oil absorption index in the dough, resulting in a decreased fat content in the final product. The reduction in oil absorption occurs because xanthan gum affects the microstructure of the surface by forming a protective layer, which strengthens the surface structure and prevents oil absorption through a capillary mechanism [17].

3.4. Protein Contents

Table 2 shows that the protein content of rice crackers with different leaf treatments ranged from 10.50% to 12.29%. The addition of torbangun leaves resulted in the lowest protein content, ranging from 10.50% to 10.75%, while the addition of moringa leaves produced the highest protein content, ranging from 11.95% to 12.29%. The differences in the protein content of the rice crackers were due to variations in the protein content of the leaves used. Moringa leaves contain 5.1 g/100 g of protein. katuk leaves 6.4% [2]. and torbangun leaves 1.3 g/100 g [9]. The protein content of raw materials directly influences the nutritional composition of the final product [18]. An increase in protein content to 8.9%, 9.65%, 10.25%, 11.36%. and 12.46% was observed with the addition of 3 g, 6 g, 7 g, 10 g, and 13 g of moringa leaves [19]. The addition of xanthan gum had no significant effect on protein.

Table 2. The chemical analysis of rice crackers

Treatment		Fat	Protein	Carbohydrate
Types of Leaves	Xanthan Gum	(%)	(%)	(%)
Moringa	0.5%	6.10	11.95	76.40
	1.0%	5.62	12.08	76.42
	1.5%	4.50	12.29	77.15
Torbangun	0.5%	4.26	11.15	81.77
	1.0%	3.78	10.50	82.55
	1.5%	3.51	10.60	82.28
Katuk	0.5%	5.23	11.60	79.27
	1.0%	4.31	11.25	79.76
	1.5%	4.08	11.13	79.52

3.5. Carbohydrate Content

Table 2 shows that the carbohydrate content of rice crackers varied depending on the type of leaf used. Rice crackers with moringa leaves had the lowest carbohydrate content (76.40%–77.15%). followed by those with katuk leaves (79.27 –79.76%). while torbangun leaves resulted in the highest carbohydrate content (81.77%–82.28%). This variation is due to differences in the ash, fat, and protein content of the rice crackers. Carbohydrate levels tend to decrease as the content of other components, such as ash, protein, and fat, increases [19]. In a study by [20], biscuits made from 100% wheat flour had a higher carbohydrate content compared to biscuits made from 97% wheat flour and 3% moringa leaf flour, as the latter contained higher levels of fat, protein, and ash.

The difference in carbohydrate content in rice crackers is also influenced by the carbohydrate content of xanthan gum. Xanthan gum is a polysaccharide, making carbohydrates its largest structural component. It is an extracellular polysaccharide secreted by the bacterium Xanthomonas campestris, consisting of large molecules with repeating units. Its chemical structure includes a main chain with (1,4) D-glucose bonds and branched chains composed of mannoacetate and glucuronic acid [2].

4. CONCLUSION

Rice crackers with different leaf types and xanthan gum concentrations had a significant effect ($P<0.05$) on moisture content, ash content, fat content, protein content, and carbohydrate content. The highest moisture content was found in moringa leaf rice crackers with 1.5% xanthan gum (2.93%), while the highest ash content was also observed in moringa leaf rice crackers with 1.5% xanthan gum (3.12%). The highest fat content was recorded in moringa leaf rice crackers with 0.5% xanthan

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gum (6.10%), whereas the highest protein content was obtained in moringa leaf rice crackers with 1.5% xanthan gum (12.29%). Meanwhile, the highest carbohydrate content was found in torbangun leaf rice crackers with 1% xanthan gum (82.55%).

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