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QUINOA AS FUNCTIONAL INGRADIENT IN THAI INDIGENOUS SWEET FERMENTED RICE (KHAO-MAK)

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Abstract: Fermented rice called “Khao-Mak” is one of the most popular traditional foods in Thailand. Khao-Mak is low in protein and fiber content. This study aimed to evaluate the possibility of using quinoa as a functional ingredient in Khao-Mak. Five formulas of Khao-Mak were prepared by replacing waxy rice with quinoa at 0, 30, 50, and 100 % were fermented using the traditional starter culture (Look-Pang powder) (2% of the mixture). The proximate compositions, physical characteristics, and sensory evaluation of Khao-Mak were determined. The result revealed that the waxy rice could be replaced by quinoa in Khao-Mak for up to 30%. The fermented time was one day comparable to a Kho-Mak without adding quinoa and commercial formula. The appearance of Khao-Mak with 30% quinoa addition had good clump, light yellow, good odor, and soft texture with a small amount of water syneresis called “Nam-Toy”. The pH, total soluble solid, and reducing sugar of Khao-Mak with 30% quinoa were 3.46, 27 °brix, and 24.86 mg/g, respectively. The sensory scores of Khao-Maks with 30% quinoa were no significant difference compared with the 0% quinoa and commercial formula. The protein and dietary fiber content of Khao-Mak (30% quinoa) increased from 4.30% (control) to 11.86% for protein and from 0.1% to 4.02% for dietary fiber. This study suggested that quinoa could be used as a source of protein, fiber, and a functional ingredient in Khao-Mak preparation that could provide a high nutritional value for the health benefits of a traditional sweet dessert.

Keywords: curriculum, General Education curriculum, curriculum implementation, phenomenological study

Introduction

Thai Indigenous Sweet Fermented Rice, known as "Khao-Mak," is a traditional sweet dessert in Thailand. This delicacy is made by fermenting cooked glutinous rice with Look-Pang, a traditional fermentation starter, for 1-2 days. Khao-Mak has a unique taste with a slight alcohol flavor and is enjoyed by people of all ages. Apart from being a delicious dessert, Khao-Mak also offers health benefits due to the presence of Look-Pang, which contains beneficial microorganisms such as Aspergillus species, Rhizopus species, Saccharomyces cerevisiae, and Candida species These active bacteria function as probiotics and provide health benefits to the consumer when consumed in adequate amounts. While Khao-Mak is known for its probiotic properties, it is also high in carbohydrates and has a low glycemic index (GI). To address this problem, it is necessary to find

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methods that can enhance the health benefits of Khao-Mak. One potential solution lies in the incorporation of Quinoa into Khao-Mak.

Quinoa is a grain widely used as a staple food in Andean communities and has been cultivated for over 5,000 years. It is known for its high protein content, gluten-free nature, and various bioactive phytochemicals such as dietary fiber, carotenoids, phytosterols, and polyphenols. Quinoa is also rich in vitamins and minerals. Quinoa is often used as an alternative to rice for individuals seeking healthier food options. However, its use in traditional Thai food, such as Khao-Mak, can be a valuable way to develop nutritious and value-added dishes that can be enjoyed by people of all ages. By incorporating Quinoa into Khao-Mak, researchers aim to create fusion food products that not only increase nutritional value but also offer new culinary experiences. The findings from this study can contribute to the creation of innovative and healthy food options globally.

Materials and Methods

Glutinous rice and Look-Pang were all purchased from a local market in Mahasarakham. White quinoa purchased from supermarket in Mahasarakham. Glutinous rice were soaking in water for 4 to 10 hours then steaming over simmering water to cooked. Quinoa were cooked by boil in water for 15 minutes, remove from heat and covered for 10 minutes. Cooked glutinous rice and Cooked quinoa were mixed as various ratio in 5 treatment : Quinoa added 0%,30%,50%,70% and 100% of Quinoa. The batter was mixed with Look-Pang 0.2 % w/w of sample, and fermented in the plastic cup at room temperature for 1 day. And keep in refrigerator at 5-8 ^{o}C for analyzed. (figure 1)

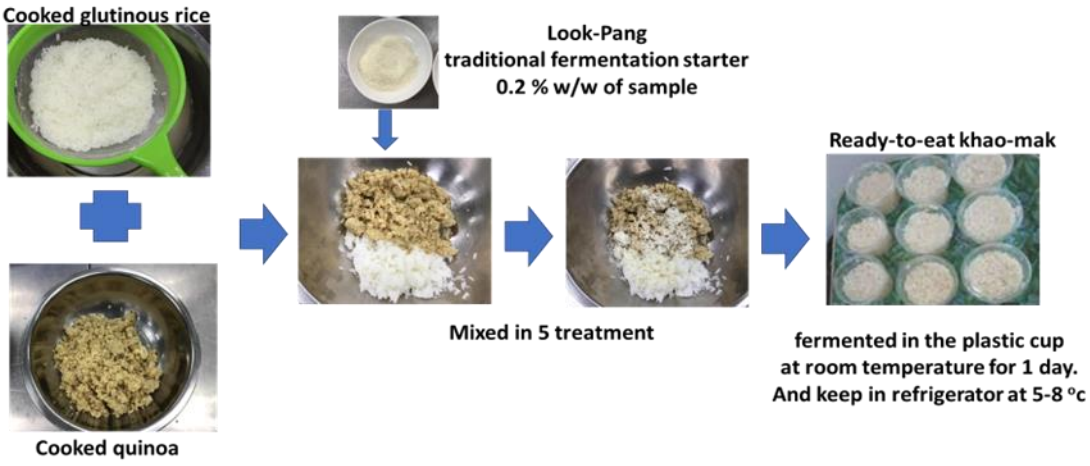

Figure 1. Khao-Mak Preparation Process

Characteristic Analysis

Five treatments of Khao-Mak were prepared as described previously for analyses. The total acid ,The total soluble solid, % Alcohol , reducing sugar and color.

Sensory evaluation

Five treatments of Khao-Mak were sensory evaluation with 30 untrained panelists. Evaluated the sample using nine point hedonic scales.

Data Analysis

The research design of this study is using Complete Randomized Design (CRD) and sensory evaluation using Randomized Complete Block Design (RCBD). Properties analysis were carried out in three replicates. The data were subjected to Analysis of Variance ($p \leq 0.05$). Mean with significant differences were separated by DMRT.

Results and Discussion

This picture showed glutinous rice and quinoa mixed together to create Khao-mak in five treatment. Their general characteristics were different but All Treatment can be fermented into Khao-mak within a 24-hour. All Khao-mak maintains its grain appearance with a pale yellowish-white color, a pleasant aroma with mild alcohol and a small amount of clear liquid called “Nam Toy" The texture of the Khao-mak remains soft, slightly crumbly and it has a sweet taste. Moreover, it was found that increasing the proportion of quinoa in Khao-mak leads to fermented Khao-mak with a sour taste , a stronger smell of quinoa and deep yellow color. The texture is drier and coarser. Reflecting the fermentation process influenced by the low starch content. All treatments of Khao-mak showed no presence of mold and no rancid smell.

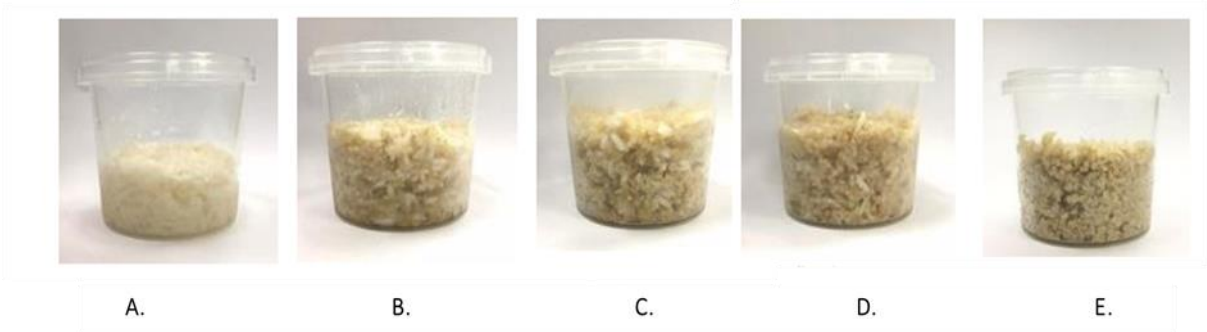

Figure 2 Khao-mak with Cooked quinoa added A. 0% B. 30% C.50% D.70% E.100% Quinoa

Table 1 Khao-mak chemical characteristic in difference % of cooked quinoa

Treatment % cooked Quinoa (w/w)	Chemical Characteristic of khao mak			
	Total soluble solid (^{o}brix)	Reducing sugar (mg/g sample)	Total acid (%)	Ethyl Alcohol (%)
0	32.26±0.05^a	92.93±2.25^d	0.53±0.01^a	0.00±0.00^a
30	27.00±0.00^b	96.18±0.96^d	0.48±0.00^b	0.51±0.00^b
50	25.06±0.05^c	39.87±0.53^c	0.63±0.00^c	0.61±0.00^c
70	22.80±0.00^d	26.50±0.86^b	0.83±0.00^d	0.80±0.00^d
100	12.03±0.05^e	8.65±0.05^a	1.16±0.03^e	0.52±0.00^b

*Values are shown in mean ± SD of triplicate measurement

**means having different superscript letters within a same column are significantly different ($p \leq 0.05$).

Based on Table **1**, the research findings indicate that the quantity of quinoa in khao mak has a significant impact on various chemical characteristics. Specifically, an increase in the amount of quinoa leads to a slight rise in the percentage of Total Acid. On the other hand, a higher quinoa content in the formula results in a more pronounced decrease in both Total Soluble Solids and Reducing Sugar.

Furthermore, the results concerning the percentage of Ethyl Alcohol demonstrate a clear trend: as the quinoa content in khao mak increases, the percentage of Ethyl Alcohol also rises. However, it's worth noting that khao mak with **100%** quinoa had the lowest percentage of Ethyl Alcohol, which suggests that this treatment might have limited the availability of carbohydrates for fermentation.

Table 2 khao -mak Chemical characteristic in difference % of cooked quinoa

Treatment % cooked Quinoa (w/w)	Color Characteristic of khao mak			
	L*	A*	B*	total color difference ΔE*
0	68.80±0.92^e	-1.07±0.17^a	7.34±0.57^a	0.00
30	63.11±1.73^b	0.09±0.21^b	12.45±0.65^c	4.87
50	62.84±4.17^b	-0.14±0.57^b	10.86±1.01^b	5.43
70	60.04±2.00^{ab}	0.45±0.49^{bc}	13.30±0.35^c	7.70
100	57.53±0.73^a	0.90±0.15^e	13.26±0.52^c	10.15

*Values are shown in mean ± SD of triplicate measurement

**means having different superscript letters within a same column are significantly different ($p \leq 0.05$).

According to the findings presented in Table 2, it is evident that the quantity of quinoa in khao mak plays a crucial role in determining its color characteristics. Specifically, a decrease in the L* value darkens the color of khao- mak. Moreover, as the amount of quinoa increases, there is a slight rise in

the B* value. Conversely, a higher content of quinoa in the formula leads to a more pronounced decrease in the A* value.

Table 3 khao-mak Sensory characteristic in difference % of cooked quinoa

Treatment % cooked Quinoa (w/w)	Sensory Attribute				
	color	flavour	taste	texture	Over all accept
0	7.03±1.18[a]	6.51±1.66[a]	6.84±1.17[a]	6.69±1.70[a]	7.09±1.28[a]
30	6.72±1.64[b]	5.81±1.95[ab]	6.69±1.59[a]	6.42±1.54[a]	6.57±1.69[ab]
50	6.03±1.42[b]	5.03±1.75[b]	5.78±1.38[b]	5.84±1.46[ab]	5.87±1.63[bc]
70	5.48±1.52[bc]	5.45±1.83[bc]	5.42±2.00[b]	5.36±1.91[bc]	5.48±2.01[cd]
100	4.87±1.84[c]	4.24±2.06[c]	4.36±1.61[c]	4.81±1.75[c]	4.75±1.90[d]

[*]Values are shown in mean ± SD of triplicate measurement

[**]means having different superscript letters within a same column are significantly different ($p \leq 0.05$).

The study presented in Table 3 demonstrates the impact of quinoa percentage on the sensory characteristics and overall preference of Khao mak. Here are the key findings: Sensory Characteristics: The percentage of quinoa had a significant effect on the sensory characteristics of Khao mak. This includes factors like color, aroma, taste, and texture. Color: Increasing the amount of quinoa in Khao mak influenced the color of the Khao mak. Lowering the percentage of quinoa led to a decrease in acceptance of the Khao mak color. Aroma: The quantity of quinoa had an impact on the aroma of Khao mak. Reducing the percentage of rice resulted in a lower acceptance of the aroma. The delightful aroma of Khao mak is attributed to the fermentation of Hansenula and Saccharomyces yeasts during the fermentation of glutinous rice. These yeasts convert sugars into esters and alcohols, contributing to the appealing aroma of the dish. Taste ,Texture and Overall Preference: Khao mak with 0% quinoa and 30% quinoa received the highest scores, and there was no statistically significant difference between them.

Based on these findings, the study suggests that adding 30% quinoa to Khao mak is appropriate to achieve the highest flavor, taste, texture, and overall preference scores, with no significant difference compared to sticky rice made from glutinous rice. This means that incorporating quinoa into the dish can enhance its sensory characteristics and overall appeal without compromising on taste and texture.

Table 4 Nutrition value of 30% Quinoa added khao-mak and commercial khao-mak

Nutrition	Khao-Mak commercial	Khao-Mak 30% quinoa
Moisture content(%)	60.74	58.82
Protein(%)	4.30	11.86
Fat(%)	0.34	0.83
Carbohydrate(%)	34.31	23.58
Food fiber(%)	0.1	4.02
Ash(%)	0.31	0.89

Note: The data of Khao-Mak commercial Nutrition value are from Koch Cha Sarn of Science Vol.42No.2 July-December 2020

Table 4 presents the nutritional values of commercial Khao mak compare with an khao mak addition of 30% quinoa. The results indicate that Khao mak with quinoa possesses higher nutritional content compared to regular commercial Khao mak, particularly in terms of protein, dietary fiber, and fats. These nutrients are essential for the body's health and overall nutrition.The inclusion of quinoa in Khao mak contributes to its increased nutritional value, as quinoa is known to be abundant in antioxidants, which play a vital role in neutralizing harmful free radicals within the body. Furthermore, quinoa stands out for its high levels of calcium and dietary fiber when compared to other grains. These findings suggest that quinoa can be effectively used as a functional ingredient in Khao mak, with an optimal incorporation rate of 30%. This percentage allows the quinoa to ferment well into Khao mak, ensuring a visually appealing and sensorially pleasing product that does not differ significantly from regular commercial Khao mak while offering enhanced nutritional benefits.

Conclusion

Quinoa can use as ingradient of Khoa Mak all five different formulas can be fermented to ready to eat Khoa- mak in just one day. Additionally, it was discovered that the most suitable formula for producing Khoa Mak with quinoa at 30%. Quinoa can use as functional ingradient of Khoa Mak, Additionally, the Khoa -Mak from 30% quinoa had higher nutritional values, such as protein and dietary fiber, and low carbohtdrate when compared to commercial Khoa Mak.

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