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High Fiber Enrichment of Khao-Tang as a Thai Style Rice Cracker using Red Seaweed (*Gracilaria gracilis*)

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Absract The develop a fibre enriched Khao-Tang, a Thai style rick cracker that is desireable for adults and children was investigated. Five different amounts of powdered *Gracilaria* (red algae) were added to 200 grams of Jjasmine rice and 2 grams of cassava flour (0, 5, 10, 15 and 20 grams or 2.5%, 5.0%, 7.5% and 10%).Complete randomized design (CRD) was used to determine the optimum level of powdered Gracilaria for rice crackers.Physicochemical characterization was determined for all treatments. Sensory acceptability was undertaken with 30 untrained panelists. Results of sensory evaluation, using 9-point hedonic scale, found that the highest color score was derived from crackers containing 2.5-5%, powdered Gracilaria. The highest texture score was found in the control.The highest overall score for acceptability was found in crackers containing 2.5% powdered *Gracilaria*.Increasing the amount of powdered Gracilaria in the rice crackers inproved the fibre content, but product quality slightly deceased, in terms of texture, color and overall acceptance.The study showed that rice crackers containing 2.5% powdered Gracilaria should be the optimum formula to consider, having a hedonic score of 7.00±1.11. In 100 gram samples, moisture, protein, lipid, carbohydrates, fibre and ash content were 3.92±0.13g, 7.60±0.17g, 17.80±2.12g, 66.91±2.12g, 2.34±0.42 g, and 1.40±0.14g, respectively. Color values for L* a* and b* were 19.88±0.69, -1.02±0.39 and 5.97±0.39, respectively. Its fracturability and energy were 10.35±0.84 N and 509.27±8.96 kcal/g, respectively.

Keywords: High fiber- enrichment, seaweed, *Gracilaliagracilis*, Rice Cracker

Introduction

Rice is the staple or main food for many people in Thailand, and other Southeast Asian countries. There are several methods to obtain the rice as desired (Bureau of Rice Research and Development, 2002). Difference method for rice cooking has created new products. Khao Tang, for example, is a new product, created by Thai people through theirroutine cooking culture. It is a by-product of cooking rice with a pan. When cooked rice is taken out of the pan,

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some dried rice is scorched on the bottom of the pan, and becomeskhao thung, a product with a yellow coloration, able to be kept for a long time. It was later produced for sale as a variety of snacks; as consumption of healthy snacks in Thailand is becoming more popular and a rapidly growing market (Suvannasungkha, 2001). Red seaweedis in a genus *Gracilaria, and* represented by more than 300 species, of which 160 have been accepted taxonomically. The macroalgae belonging to this genus are important for industrial and biotechnological uses, and considered economically valuable resources, because of their ability to achieve high yields of commercially valuable biomass (Capo *et al*., 1999).*Gracilaria* spp. mainly serve as a raw material from which agar or carrageenan is extracted out for use in the food industries or in the production of tissue culture media (Glickman, 1987; Jahara and Phang, 1990). *Gracilaria* spp.have low calorie content, but are rich in vitamins, minerals and dietary fibres (Ito and Hori, 1989). This species also containsprotein, vitamins and mineral essential for human nutrition, and are extensively consumed especially by people living in the coastal areas (Jensen, 1993).

Normally, Khao tang contains only rice. Vegetable powders are occasionally added, but are not common in ready to eat snacks. It is known that red seaweed, *G. gracilis* is a good source of carotenoid pigments and dietary fibres (Briggs and Smith, 1993; Ito and Hori, 1989); thus, providing many good health benefits. The intention is to create a new rice cracker product, focussing on increased nutritional benefits to consumers. This, not only increases snack alternatives for consumes, but also provides a healthy option. Therefore, using powdered *Gracilaria* to enrich the fiber content of Khao Thung products became aninterest. In this study, the objective was to determine the most appropriate percentage of red seaweed, *G. gracilis* to use in a rice cracker formulation.

Materials and methods

Preparation of Gracilaria Powder

Fresh red seaweed, *G. gracilis* was collected from local market in Trat Province, Thailand, and maintained at temperature of 5 ±2 °C before trial. It was then cleaned, blanched in boiled water at 80 ℃ for 1 minute, and dried at 60±2 ℃ for 8 hours in hot air oven (Binder, Germany). The seaweed was then ground to fine powdered particles, using a blender and an ultra centrifugal mill. The powdered red seaweed was then kept in a sealed polypropylene bag and stored at room temperature, before trial.

Basic Components of Rice Cracker

Preparation of rice crackers followedmethods, written by Tachasiriwichai (2014), with some modifications.Five different amounts of powdered red seaweed were determined, and then each amount was added to 200 g of jasmine rice, 2 g of cassava flour and 400 mL of water (Table 1).

Formulation of Rice Cracker Products, Supplementedwith Red Seaweed, G. gracilis

To determine optimum percentage of *Gracilaria* powder in rice crackers, complete randomized design (CRD) was used. Amounts of Gracilaria powder varied, by percentage (Table 1) for 5 separate treatments or product trials. Means and standard deviations of experimentwere calculated. Data was analyzed using ANOVA. Significant differences among treatments werecompared, using average values, with Duncan's new multiple range test, at a confidence level of 95%.

Preparation ofRice CrackerSamples

Two hundred grams of broken jasmine rice were cleaned for 2 times before being cooked with 400 mL of water. *Gracilaria* powder at 2.5, 5, 10, 15 and 20 grams, respectively, was immersed in water for 10 minute, prior to mixing with jasmine rice. All ingredients mentioned above were cooked for 20 min using an electric rice cooker. The resulting cooked rice was poured into a 20x28 cm^2 tray, cooleddown, but not cold, then mixed well with cassava flour. The mixture was then kneadedinto a dough consistency, placed between two sheets of cling film, and flattened into a 2 mm thick sheet, using a rolling pin. The sheet was then dried in a hot air oven, at 60◦C, for 8 hours. After this time, the sheet was cut into cracker size strips (of 1.5x1.5 inches) and returned to the hot air oven to continue drying at 60 ◦C for 4 additional hours (Figure 1). The strips were then deep fried with palm oil at 190˚C for 1 minute, and set aside for 5 minutes, to drain excess oil. Samples were packed in sealed polyproplylene bags and stored at room temperature until further testing was initiated.

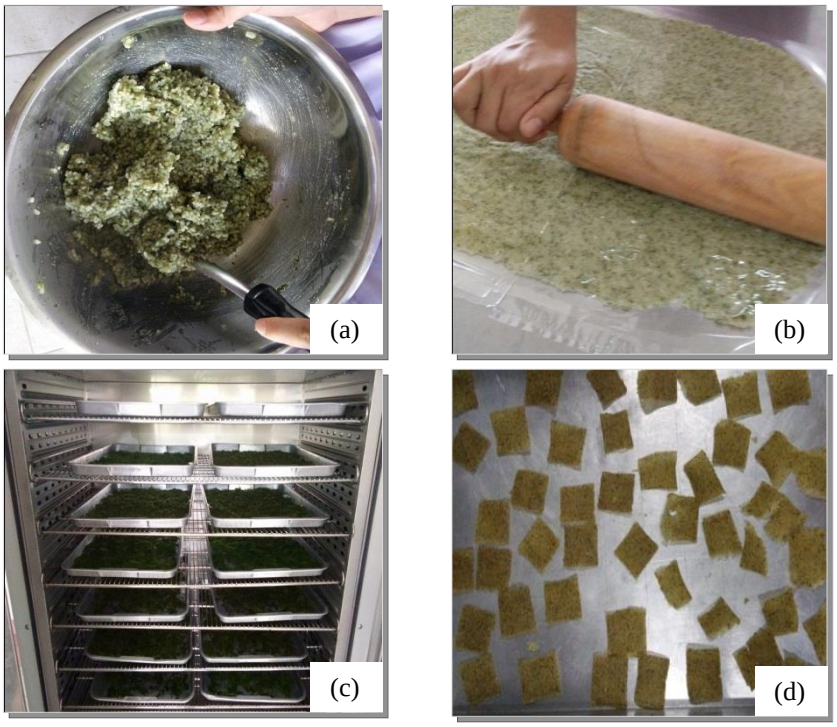

Figure 1. Process of Khao-Tang, Rice Crackers enriched with Red Seaweed, *G.gracilis* (a) mixing of all ingredients, (b) flatted in sheet, (c) dried in hot air ovenand (d) Rice Crackers product before deep fried.

Table 1. Formulation for Rice Crackersenriched with Red Seaweed, *G.gracilis*

Treatments	Ingredients		
	Gracilaria powder (g)	jasmine rice (g)	cassava flour (g)
1	0 (0%)	200	2
2	5 (2.5%)	200	2
3	10 (5%)	200	2
4	15 (7.5%)	200	2
5	20 (10%)	200	2

Physical and Chemical Quality Analysis

The cracker colour was determined by CIE colour scales L∗, a∗ and b∗using a lab digital colorimeter (Model ZE-2000, Nippon, Japan).Color values were recorded as L* = lightness (0 = black, 100 = white);a* (-a* = greenness, +a* = redness); b* (-b* = blueness, +b* = yellowness).Diet energy of the samples was measured using abomb calorimeter (6100 instruction manual, PARR, USA).Moisture, fat content and crude fibre were determined according to AOAC standard methods (Association of Official Agricultural Chemists, 2010). The analysis included performing four replicates for each sample.

Determination of Microbiological Quality

A microbiological analysis was conducted to determine total microorganism in the cracker.The total viable plate countmethod of knowing and counting thenumber of viable microorganism present in the sample wasadopted as described by BAM (2001). All colonies on Plate Count Agar (PCA) were counted as TVM, while yeast and mould counts were obtained from Potato Dextrose Agar (PDA).

Sensory Evaluation

Sensory evaluation was determined using a 9-point hedonic scale. Attributes that were evaluated include: appearance, color, odor, taste, texture, and overall acceptability; where 9 = extremely liked and 1 = dislike extremely. Thirty untrained panelists were selected from students and staff of Rajamangala University Tawan-ok, Chanthaburi Campus. The sensory evaluation wasperformed in a laboratory setting, with clean sensory cabinets containing fresh water;carried out, using a complete randomized design with triplicates.

Results

Physical Properties of the Analysed Rice Cracker

Product appearances for all treatment are shown in Figure 2. Physical properties are shown in Table 2, showing statistically significant differences ($p \leq 0.05$) for all treatments. Minimum fracturability values were seen in a control group (5.51 ± 0.86 N), with the maximum ability found incrackers containing10% *Gracilaria* (10.35 ± 0.84 N). This indicated that gelatin content of *Gracilaria* has an effect on crispness. Lightness (L*) became lower when *Gracilaria* was increased. This may be due to influence from the dark pigment

of *Gracilaria* which gave these algaeits characteristic of green-brown color. Within the range of red (+a*) to green (-a*) tonality, green was more predominant when increasing the *Gracilaria* percentage. As for therange of yellow (+b*) to blue (-b*), the lowest yellow (b*) value was observed in the control.

Table 2. Mean physical parameters of the analysed Rice Cracker

Content of *Gracilaria*(%)	Fracturability (N)	Color parameter		
		L*	a*	b*
0	5.51 ± 0.86^{a}	32.29 ± 1.10^{e}	1.05 ± 0.53^{b}	0.52 ± 0.98^{a}
2.5	6.22 ± 0.98^{a}	28.67 ± 1.27^{d}	-1.42 ± 0.55^{a}	6.64 ± 1.54^{c}
5.0	8.64 ± 1.16^{c}	24.10 ± 0.87^{c}	-1.01 ± 0.68^{a}	5.55 ± 0.61^{b}
7.5	7.61 ± 1.21^{b}	22.68 ± 0.57^{b}	-1.28 ± 0.56^{a}	6.31 ± 0.92^{bc}
10.0	10.35 ± 0.84^{d}	19.88 ± 0.69^{a}	-1.02 ± 0.39^{a}	5.97 ± 0.39^{bc}

Value are expressed as mean ±standard deviation,
Mean followed by different letters in the same column differs significantly ($p \leq 0.05$)

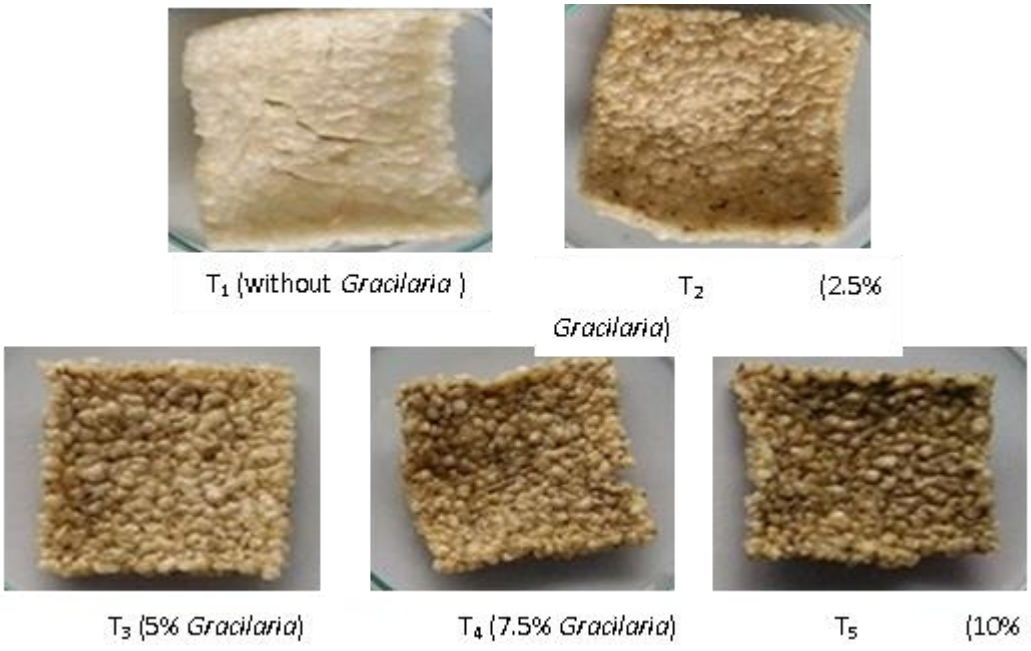

Figure 2. Rice cracker samples with different *Gracilaria*content

Proximate Analysis

Results of the proximate analysis are provided in Table 3. Moisture content of protein, lipid and carbohydrate for all the product samples were identitied and not statistically significant different (P ≥0.05). Moisture content of all rice cracker samples showed a varied from 3.6 to 4.65 g. Protein and carbohydrate content were attributed mainly to the rice and cassava flour, amounts of each being identical for all treatments. Therefore, there was no significant difference with protein and carbohydrate content for all rice cracker samples. However, protein did show a trend to higher values, when amount of *Gracilaria* was increased. The main source of lipid content in all cracker samples was palm oil rather than from *Gracilaria* raw ingredients. Palm oil is used in a fryin process, a requirement for all crackers, to improve palatability. Fibre was highest in test samples containing 10% *Gracilaria*(P ≤0.05); again tending to become higher when *Gracilaria* was increased. Energy content was highest in the control sample when compared to the experimental samples (P ≤0.05). As percentage of *Gracilaria*, the powder increased from 0 to 10%, the energy content decreased as approximately at 6 to 11%.

Table 3. Proximate analysis ofthe rice cracker samples (per 100 gram)

Content of Gracilaria (%)	Moisture^{ns} (g)	Protein^{ns} (g)	Lipid^{ns} (g)	Carbohydrate^{ns} (g)	Fiber (g)	Ash (g)	Energy (Kcal)
Control	3.65±1.59	7.40±0.49	20.13±7.59	66.86±6.03	0 .99±0.01^{a}	0.95±0.05^{a}	541.57 ±56.41^{b}
2.5	4.58±0.46	7.39±0.14	16.78±0.47	68.85±0.90	1.11±0.06^{a}	1.25±0.14^{ab}	505.88 ±6.50^{a}
5.0	4.65±0.30	7.81±0.61	18.62±6.66	66.27±7.18	1.22±0.08^{a}	1.40±0.32^{b}	484.73 ±11.99^{a}
7.5	4.34±0.14	7.68±0.44	11.98±3.12	73.26±2.64	1.31±0.08^{a}	1.43±0.03^{b}	478.31 ±13.92^{a}
10	3.92±0.13	7.60±0.17	17.80±2.12	66.91±2.12	2.34±0.42^{b}	1.40±0.14^{b}	509.27 ±8.96^{a}

Value are expressed as mean ±standard deviation,
Mean followed by different letters in the same column differs significantly (p ≤ 0.05)

Microbial contamination

The microbial count of all sample treatment after 7 days of storage in polyethylene pack with paperboard is shown in Table 4. It was observed that microbial content of total viable microbiology (TVM) for all the product samples were not statistically significant different (P >0.05). The TVM counts were found to be lower than 10^4 CFU/g., yeast and mould counts were not detected.

Table 4. Microbiological count ofthe rice cracker samples

Conten of *Gracilaria* (%)	**TVM (CFU/ml)**	**Yeast (CFU/ml)**	**Mould (CFU/ml)**
0	420	ND	ND
2.5	295	ND	ND
5.0	275	ND	ND
7.5	200	ND	ND
10.0	300	ND	ND

ND = Not detected

Sensory Evaluation

Sensory scores of the panelists on their sensory evaluation, for each treatment, are shown in Table 5. Analysis of variance indicated no significant difference in the acceptability of aroma and taste between the five treatments (Table 4). Mean hedonic score for most treatments was around 6, indicating that aroma and taste were “liked slightly”. The study found that increasing the amount of Gracilaria does not affect aroma and taste of analysed crackers, likely because Gracilaria has no unique smell and taste. Highest color score was observed in treaments containing 2.5-5.0% Gracilaria. Preferred texture scores resulted in a a downward trend when powdered Gracilaria was increased, and is lowest in treatments containing 10% Gracilaria. It appears to be a result of higher fracturability and lower crispness. Mean hedonic score for overall acceptance of treated products containing 2.5% powdered Gracilaria showed highest scores, with 7.00 ± 1.11; slightly higher the median point, meaning moderately liked.

Table 5. Mean sensory scores of analysed Rice Crackers

Content of *Gracilaria* (%)	Sensory evaluation				
	Color	Aroma ^{ns}	Taste ^{ns}	Texture	Overall Acceptance
0	5.67±1.56^{a}	5.87±1.47	5.77±1.35	6.43±1.40^{b}	6.10±1.37^{ab}
2.5	6.70±1.41^{b}	6.07±1.43	5.80±1.71	5.77±1.52^{ab}	7.00±1.11^{c}
5.0	6.87±1.83^{b}	7.37±1.23	5.70±1.64	6.13±1.69^{ab}	6.37±1.29^{bc}
7.5	6.03±1.32^{ab}	5.70±1.36	5.53±1.65	5.43±1.94^{a}	5.73±1.61^{ab}
10.0	5.53±1.79^{a}	6.93±1.58	5.63±1.24	5.47±1.71^{a}	5.60±1.69^{a}

Value are expressed as mean ±standard deviation,
Mean followed by different letters in the same column differs significantly ($p \leq 0.05$)

Discussion

As result, the product appearances showed statistically significant differences for all treatments. It is indicated that gelatin content of *Gracilaria* be effected on crispness as reported by Khao Narong and Kochul (2003) who staed that gelatin inhibited gelatinization of starches, resulting in low viscosity and less starch deposition. The proximate analysis showed moisture content of protein, lipid and carbohydrate for all the product samples were not statistically significant different. Zydenbos and Humphrey-Taylor (2003) reported that moisture content of all rice cracker samples, varied from 3.65to 4.65 g. Result showed protein trended to higher values, when amount of *Gracilaria* was increased. Renaud and Luong-Van (2006) stated this is probably due to the protein content in Gracilaria species ranging from 5.6% to 30%. The microbial count of all sample treatment were similar as the standards of microbiology for ready-to-eat food, as determined by Thai community product standard (Ministry of Industry, 2003). It concluded that appropriate-use percentage of powdered Gracilaria in Khao-Tang, Thai style rice cracker formulation was 2.5%, with highest scores for overall acceptance, and meaning this product is moderately liked.

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