



## Soy Crisps Incorporated with Red Seaweed, *Kappaphycus alvarezii*

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### ABSTRACT

*Kappaphycus alvarezii* (KA), an underutilized seaweed with potential benefits, is particularly used to extract kappa-carrageenan in the food industry. There is a notable absence of commercially available snacks that incorporate KA. This study aimed to develop soy crisps incorporating different concentrations of KA powder (0%, 2.5%, 5%, 7.5%, and 10%) and to determine the best formulation for addressing the gap. KA-incorporated crisps showed darker colour with more redness and yellowness and ideal texture. The crisps with 5% KA (F3) received significantly highest sensory scores for texture, taste, and overall acceptance ( $p < 0.05$ ). F3 crisps had higher ash, protein, fibre, and carbohydrates, and lower fat compared to control (F1), while providing more energy. In conclusion, these findings highlight the potential of KA-incorporated crisps as a nutritious and palatable snack option.

### INTRODUCTION

A snack is a small serving of food or drinks consumed between the main meals [1]. Snacking is a prevalent daily habit globally, with 71% of consumers indulging at least twice a day [2]. Snacks come in various forms, from fresh to packaged and processed foods, with popular choices like tortilla chips, potato chips, and nuts [3]. While some snacks offer little nutritional value and are considered junk food, there's a growing focus on creating nutritious options that meet consumer demands for healthier alternatives [3]. This includes incorporating vegetables like seaweed, which is rich in nutrients like protein and minerals [4]. *Kappaphycus alvarezii* (KA) is a type of red seaweed famous as a kappa-carrageenan source and widely cultivated in Sabah [5]. The extraction of red seaweed is mostly related to agar and carrageenan, which are widely employed as additives in various industrial segments, particularly in the food industry. The study is aimed to develop soy crisps incorporated with 0%, 2.5%, 5%, 7.5%, and 10% of KA. The physical properties, sensory attributes, and nutritional composition are evaluated. A four-week shelf-life study was also conducted to assess the shelf-life of the soy crisps incorporated with KA.

### MATERIALS AND METHODS

#### Preparation and formulation of KA-enhanced soy crisps

Fresh KA was obtained from Semporna, washed and cut into small pieces, dried at 40°C for 24 hours, ground and sieved. Roasted soy powder was made by washing soybeans, roasting, grinding, and sieving. Soy crisps were prepared using formulations based on wheat flour, roasted soy powder, margarine, brown sugar, paprika powder, and water. KA replaced wheat flour in four formulations (2.5%, 5%, 7.5% and 10%), while one served as the control (0%). After mixing and shaping, the dough was baked at 180°C for 12 minutes.

#### Physical, sensory, and nutritional analyses of KA-enhanced soy crisps

Physical analyses included measurements of colour, texture, thickness, and water activity [6]. The sensory evaluation involved a nine-point hedonic scale test with 50 untrained panellists assessing texture, taste, aftertaste, aroma, colour, and overall acceptance. The best formulation was selected to further analyze proximate composition, dietary fibre, energy content, and shelf-life.

The proximate analysis included moisture, ash, crude fat, protein, crude fibre, and carbohydrate determination. Total dietary fibre content was analysed following the AOAC method, while energy content was calculated using Atwater factors.

### Shelf-life analysis

Shelf-life analysis over four weeks involved water activity, moisture content, and colour analysis of crisps packed in low-density polyethylene zipper bags.

### Statistical analysis

Statistical analysis was conducted using SPSS, with one-way ANOVA and Tukey's HSD test.

## RESULTS AND DISCUSSION

**Table 1** illustrates the hardness and fracturability of soy crisps incorporated with KA. The hardness and fracturability of soy crisps were highest with no addition of KA powder and decreased with increasing KA powder concentration. F5 had the lowest fracturability, indicating a weak gluten network and had disruption by KA powder [7].

**Table 1.** Hardness and fracturability of soy crisps incorporated with seaweed *Kappaphycus alvarezii* and control (without seaweed). F1 – No seaweed powder, F2 – 2.5%, F3 – 5.0%, F4 – 7.5%, F5 – 10.0%. Values are expressed as mean ± SD of triplicate measurement. Superscripts with different letters are significantly different at  $p < 0.05$  in the same column.

Formulations	Hardness (g)	Fracturability (mm)
F1	1443.61 ± 9.08 <sup>a</sup>	12.47 ± 0.10 <sup>c</sup>
F2	1165.14 ± 4.02 <sup>c</sup>	13.56 ± 0.25 <sup>b</sup>
F3	959.46 ± 7.00 <sup>d</sup>	13.81 ± 0.50 <sup>b</sup>
F4	1151.78 ± 5.16 <sup>c</sup>	14.24 ± 0.43 <sup>b</sup>
F5	1258.14 ± 8.57 <sup>b</sup>	18.77 ± 0.29 <sup>a</sup>

**Table 2.** Sensory evaluation of soy crisps incorporated with seaweed *Kappaphycus alvarezii* and control (without seaweed). F1 – No seaweed powder, F2 – 2.5%, F3 – 5.0%, F4 – 7.5%, F5 – 10.0%. Values are expressed as mean ± SD of triplicate measurement. Superscripts with different letters are significantly different at  $p < 0.05$  in the same column.

Formulations	Attributes					
	Colour	Aroma	Texture	Taste	Aftertaste	Overall acceptance
F1	6.78 ± 1.72 <sup>a</sup>	6.92 ± 1.58 <sup>a</sup>	6.86 ± 1.64 <sup>b</sup>	6.74 ± 1.48 <sup>b</sup>	6.62 ± 1.52 <sup>a</sup>	6.74 ± 1.23 <sup>b</sup>
F2	6.64 ± 1.38 <sup>a</sup>	6.60 ± 1.54 <sup>a</sup>	6.94 ± 1.36 <sup>b</sup>	6.68 ± 1.66 <sup>bc</sup>	6.72 ± 1.57 <sup>a</sup>	6.62 ± 1.48 <sup>b</sup>
F3	6.72 ± 1.44 <sup>a</sup>	6.88 ± 1.24 <sup>a</sup>	7.92 ± 0.94 <sup>a</sup>	7.78 ± 0.932 <sup>a</sup>	7.22 ± 1.09 <sup>a</sup>	7.60 ± 0.80 <sup>a</sup>
F4	6.20 ± 2.02 <sup>ab</sup>	6.18 ± 1.92 <sup>ab</sup>	6.48 ± 1.93 <sup>bc</sup>	5.84 ± 1.91 <sup>cd</sup>	5.32 ± 1.99 <sup>b</sup>	6.04 ± 1.67 <sup>b</sup>
F5	5.56 ± 1.92 <sup>b</sup>	5.50 ± 2.02 <sup>b</sup>	5.98 ± 1.87 <sup>c</sup>	5.08 ± 1.83 <sup>d</sup>	4.64 ± 1.77 <sup>b</sup>	5.14 ± 1.74 <sup>b</sup>

## CONCLUSION

Higher concentrations of KA powder incorporation led to increased hardness and decreased fracturability of the soy crisps. Soy crisps with 5% KA were selected as the best formulation due to higher sensory mean scores than the other formulations. The incorporation of KA powder in soy crisps led to increases in moisture, ash, protein, crude fibre, carbohydrate, and total dietary fibre content, but a decrease in fat content, attributed to the low-fat content in KA. Soy crisps incorporated with KA powder have a higher caloric value compared to control soy crisps without KA powder. In conclusion, these findings highlight the potential of KA-incorporated crisps as a nutritious and palatable snack option.

**Table 2** shows no significant differences between soy crisps in aroma, colour, and aftertaste, but texture, taste, and overall acceptance showed significant differences ( $p < 0.05$ ). F1 (control) had the highest mean score for colour and aroma. F3 was selected as the best formulation due to its ideal texture, taste, and overall acceptance, as it had the significantly highest score for three out of six attributes. The panellists can accept the fishy odour of KA powder up until incorporation of 5%, further increase of seaweed concentration lowered the acceptance of the panellists.

**Table 3** displays the nutrient composition of the soy crisps incorporated with KA. Overall, the nutrient composition of F3 was significantly higher ( $p < 0.05$ ) than F1 except for moisture and crude fat content. The crude fat content of F1 was higher because carbon and nitrogen contained by carbohydrates in the wheat flour can be converted into fatty acid. Hence, the addition of seaweed by replacing the wheat flour concentration can result in a reduction of fat content in the soy crisps. The higher energy content in F3 was due to higher carbohydrate content and protein content.

**Table 3.** Nutrient composition of seaweed *Kappaphycus alvarezii* incorporated soy crisps of control and best formulation. F1 – No seaweed powder, F3 – 5.0%. Values are expressed as mean ± SD of triplicate measurement. Superscripts with different letters are significantly different at  $p < 0.05$  in the same row.

Formulation	F1	F3
Moisture (%)	1.81 ± 0.55 <sup>a</sup>	1.98 ± 0.23 <sup>a</sup>
Ash (%)	2.47 ± 0.23 <sup>b</sup>	2.91 ± 0.09 <sup>a</sup>
Crude fat (%)	19.39 ± 0.99 <sup>a</sup>	16.52 ± 0.77 <sup>b</sup>
Protein (%)	14.84 ± 0.17 <sup>b</sup>	15.77 ± 0.29 <sup>a</sup>
Crude fibre (%)	1.38 ± 0.02 <sup>b</sup>	2.03 ± 0.02 <sup>a</sup>
Carbohydrate (%)	59.64 ± 0.69 <sup>a</sup>	61.28 ± 0.30 <sup>b</sup>
Total dietary fibre (%)	30.76 ± 0.90 <sup>b</sup>	41.68 ± 0.11 <sup>a</sup>
Energy (kcal)	302.23 ± 1.85 <sup>b</sup>	311.90 ± 1.06 <sup>a</sup>

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## REFERENCES

- Hess JM, Jonnalagadda SS, Slavin JL. What is a snack, why do we snack, and how can we choose better snacks? A review of the definitions of snacking, motivations to snack, contributions to dietary intake, and recommendations for improvement. *Adv Nutr.* 2016;7(3):466-75.
- Mondelez International. 2022 Global Consumer Snacking Trends Study. 2022. Available from: [https://www.mondelezinternational.com/media/Mondelez/stateofsnacking/2022/2022\\_MD LZ\\_stateofsnacking\\_report\\_GLOBAL\\_EN.pdf](https://www.mondelezinternational.com/media/Mondelez/stateofsnacking/2022/2022_MD LZ_stateofsnacking_report_GLOBAL_EN.pdf).

3. Tumuluru JS. Snack foods: Role in diet. In: Encyclopedia of Food and Health. 1st ed. Elsevier Inc.; 2016. p. 6-12.
4. Jayakody MM, Vanniarachchy MP, Wijesekara WL. Development and characterization of a seaweed snack using *Ulva fasciata*. J Food Sci Technol. 2021;58:1617-22.
5. Matanjun P, Mohamed S, Muhammad K, Mustapha NM. Comparison of cardiovascular protective effects of tropical seaweeds, *Kappaphycus alvarezii*, *Caulerpa lentillifera*, and *Sargassum polycystum*, on high-cholesterol/high-fat diet in rats. J Med Food. 2010;13(4):792-800.
6. Aganduk AA, Matanjun P, Tan TS, Khor BH. Proximate and physical analyses of crackers incorporated with red seaweed, *Kappaphycus alvarezii*. J Appl Phycol. 2023;35:1743-9.
7. Mohammad SM, Mohd Razali, SF, Mohamad Rozaiman, NHN, Laizani AN, Zawawi N. Application of seaweed (*Kappaphycus alvarezii*) in Malaysian food products. Int Food Res J. 2019;26(6):1677-87.