FABJ

# Food and Applied Bioscience Journal

ISSN : 2286-8615
VOLUME 9 ISSUE 2
(MAY-AUGUST 2021)

FABJ

# Food and Applied Bioscience Journal

## TABLE OF CONTENTS

| TABLE OF CONTENTS | PAGE |
|---|---|
| **Comparison of total phenolic compound, antioxidant level and sensory evaluation among different forms of ginger juice**<br>Pornpimon Nunthanawanich, Jidapa Srisuwan, Yanisa Thapcharoen, Teeranart Ngamkham, Piyarat Oraphruek and Chatrapa Hudthagosol* | 1 - 9 |
| **Influence of k-carrageenan concentration on some properties of snack from ivy gourd (*Coccinia grandis*)**<br>Kitisart Kraboun, Putkrong Phanumong, Teeraporn Kongbangkerd and Kamonwan Rojsuntornkitti | 10 - 21 |
| **Antioxidant properties and encapsulation methods of astaxanthin: A review**<br>Kitisart Kraboun, Putkrong Phanumong, Teeraporn Kongbangkerd, Kamonwan Rojsuntornkitti, Manipat Saimek and Naruemon Jommark | 22 - 39 |
| **Effects of wall materials on the physicochemical and antioxidant properties of microwave-assisted encapsulation of Basella rubrafruit extract**<br>Viriya Nitteranon | 40 - 52 |
| **Evaluation of mathematical modelings of pineapple juice concentration using different combination techniques**<br>Lobdaw Saelee, Traiphop Phahom and Thanawit Kulrattanarak | 53 - 67 |

ISSN : 2286-8615
VOLUME 9 ISSUE 2
(MAY-AUGUST 2021)

Food and Applied Bioscience Journal

# Influence of k-carrageenan concentration on some properties of snack from ivy gourd (*Coccinia grandis*)

**Kitisart Kraboun[1,*], Putkrong Phanumong[1], Teeraporn Kongbangkerd[2] and Kamonwan Rojsuntornkitti[2]**

[1]*Division of Food Safety Management and Technology, Department of Science, Faculty of Science and Technology, Rajamangala University of Technology Krungthep, Bangkok 10120, Thailand.*
[2]*Department of Agro-Industry, Faculty of Agriculture, Natural Resources and Environment, Naresuan University, Phitsanulok, Thailand.*
**Corresponding author. E-mail: Kitisart.k@mail.rmutk.ac.th*
*Received: 14 July 2020, Revised: 10 August 2020, Accepted: 21 December 2020, Publish: 25 August 2021*

## Abstract

Carrageenan has been used by the food industry for their gelling, thickening and stabilizing properties, and more recently by the meat industry. This research aimed to study the effect of k-carrageenan concentrations at 2, 3 and 4% w/v of on moisture content, aw, hardness, chlorophyll content, L*, *h*° and BI values of the raw and fired snacks from ivy gourd. Pearson's correlation coefficients of moisture content, aw, hardness, chlorophyll content, L*, *h*° and BI values in the raw and fried snacks from ivy gourd were also studied. The results showed that the formula added with 4% w/v k-carrageenan led to higher moisture content and aw and hardness values of the raw and fried snacks. The L*values of the raw snacks increased with the increased k-carrageenan concentration ($P \leq 0.05$); whereas, the L* values of the fried snacks of all formulae were not significantly different ($P > 0.05$). The L* values of the raw snacks was an index for *h*° and BI, which were significantly negatively correlated with $h^o$ ($r$ = -0.954) and BI ($r$ = -0.969).

***Keywords***: Snack, ivy gourd, k-carrageenan, properties

# 1. Introduction

Ivy gourd (*Coccinia grandis*) is a tropical plant and belongs to family Cucurbitaceae, which is commonly known as ivy gourd or little gourd as well as also known as baby watermelon, gentleman's toes, and Kundru. It is native of Bengal and other parts of India. It occurs abundantly in India, tropical Africa, Australia, and throughout other oriental countries. Ivy gourd has further been utilized colossally in Ayurvedic and Unani practice in the Indian subcontinent. All parts of ivy gourd are useful for not only medicine but also in various preparations of traditional medicines like the anti-inflammatory, analgesic and antipyretic activity (Chatage and Bhale, 2012). Moreover, it consists of secondary metabolites, e. g., saponins, flavonoids, sterols, and alkaloids (Singh and Chandra, 2012). There are many researchers reported that the crude plant extract of ivy gourd indicated hepatoprotective, antioxidant, anti-inflammatory and anti-nociceptive, anti-diabetic, hypolipidemic, antibacterial, and anti-tussive activities (Hossen *et al*., 2009; Deen and Singh, 2013; Kuchi *et al*., 2014; Panchal *et al*., *2018*).

Starch-based snacks from corn, rice, and wheat are widely consumed by children and young people. They are rich in fat and carbohydrates and low in protein as well as without nutritional value (Hunt and Park, 2013). Dam and Seidell (2007) noted that people consumed the high contents of dietary carbohydrates and adipose tissue affecting body fatness, higher BMI and overweight. Therefore, snacks should be changed the production pattern from the high contents (15-25% w/w) of main ingredients such as corn, rice, and wheat, to hydrocolloids due to use lower contents (< 7% w/v) of hydrocolloids for snack production. When compared to same contents, the hydrocolloids showing higher Water absorption index (WAI) than corn, rice, and wheat (Kuchi *et al*., 2014). Carrageenan belongs to the polysaccharide group obtained from seaweed. It is composed of sodium, magnesium, and calcium, which could be bound to sulfate ester groups from D-galactose and 3,6-anhydro-D-galactose copolymers. Carrageenan plays an important role as a stabilizer (balance regulator), thickener, gelling agent, emulsifier, high compressive strength, flexural strength, and toughness. This property is widely utilized in the food industry and other industries (Murti *et al.,* 2019). The k-carrageenan has been used in this experiment because of the ability to form thermoreversible gels in the presence of gel-promoting cations ($K^+$ and $Ca^{2+}$) (Lascombes *et al*., 2016). It is widely used in the food industry for improving the texture and microstructure of gel. K-carrageenan is also used for thickening, water-binding, and gelling (Bosc *et al*., 2008). In solution, potassium ($K^+$ and $Ca^{2+}$) appeared in ivy gourd reacting with k-carrageenans could be aggregated and formed stronger gel (Chatage and Bhale, 2012). For example, Murti *et al*. (2019) reported that a 1 g k-carrageenan/100 g minced fish fish was used for crispy fish production, which it gave higher hardness and sensory values of appearance 9, smell 9, taste 9, texture 9, crunchy 9 than other guar gum and xanthan gum. Hedonic scales are well tried and tested in consumer research for capturing liking data. They have been used with consumers in preference mapping studies to capture liking scores. A mean liking score of 7 or higher on a nine-point scale is usually indicative of highly acceptable sensory quality; hence, a product achieving this score could be used confidently as a good illustration of ‘target’ quality. On this basis, products from a research set can then be selected to provide physical references to illustrate the sensory quality that realistically represents the consumers' acceptance limits (Murti *et al*., 2019)

As mentioned above, k-carrageenan and ivy gourd should be incorporated to produce a healthy snack. Therefore the aim of present study was to study the effect of addition of various carrageenan concentrations at 2, 3 and 4 % w/v on moisture content, $a_w$, hardness, chlorophyll content, L*, *h*° and BI values of the raw and fired snacks from ivy gourd (*Coccinia grandis*). The relationships of those properties were further investigated and discussed.

**Nomenclature**

| | | | |
|---|---|---|---|
| *h*° | hue angle | BI | browning index |
| k-carrageenan | Kappa-carrageenan | Chl a | chlorophyll a |
| $a_w$ | water activity | Chl b | chlorophyll b |
| N | Newton | Chl total | total chlorophyll content |
| L | lightness/darkness | b | blueness/yellowness |
| a | greenness/ redness | | |

## 2. Materials and Methods

### 2.1 Materials

Ivy gourd (*Coccinia grandis*) procured from a local market in Bangkok, Thailand. K-carrarrageenan (K-Carr) was obtained from S-100Fi, Ingredient Solutions Inc., Waldo, ME was supplied by Vechakit Chemical Co., Ltd. Phitsanulok, Thailand.

### 2.2 Preparation of dried ivy gourd powder

Ivy gourd without spoilage was sorted and washed with running tap water to remove adhering dirt. It was then cut into 1.2 mm length (perpendicularly to a segment's length). Then, it was dried in a hot air oven at 70°C for 4 h. The moisture content and $a_w$ of dried ivy gourd at the end of air drying were 12% and 0.6, respectively. Then the dried samples were ground into powder and sieved in 5 mm mesh and then powder is stored in a desiccator at room temperature, for further work.

### 2.3 Preparation of snacks from ivy gourd

The preparation of snacks from ivy gourd was described by Alimi *et al*. (2013) with some modifications. The snacks from ivy gourd using 2, 3 and 4% w/v of k-carrageenan were developed as shown in Figure 1. A 100 mL of distilled water was thoroughly blended with k-carrageenan at 2, 3 and 4 g and heated at 100°C for 2 min, which the mixture concentrations were equal to 2, 3 and 4% w/v. Then, a 5 g powered ivy gourd was thoroughly mixed with the mixtures. The mixtures containing powered ivy gourd were poured into a tray and the thickness of the mixtures was 0.5 mm (determining the thickness using a micrometer after pouring every time). After hardening, the samples were cut a rectangle 3 × 5 cm and dried in a hot air oven at 70°C for 4 h. The dried samples were deep fried in palm oil with a temperature-controlled pot at 170°C for 1 sec. The properties of the raw and fried samples were determined.

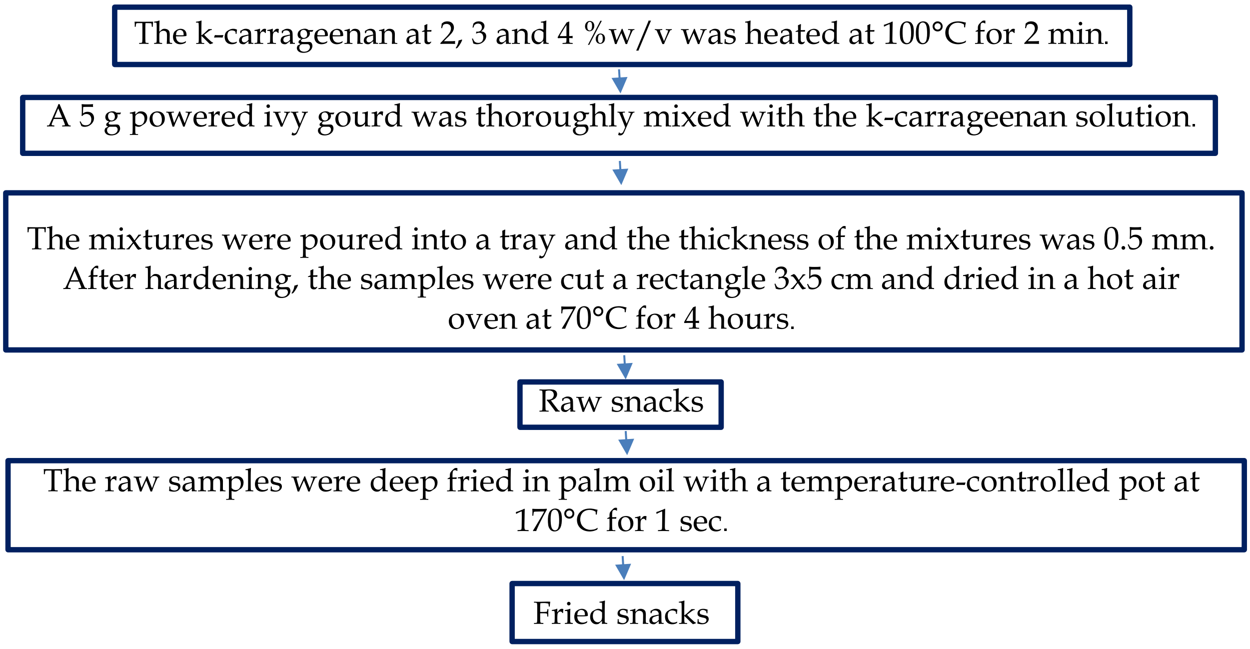


**Figure 1** Flowchart of the raw and fried snacks from ivy gourd using 2, 3 and 4%w/v of k-carrageenan

## 2.4 $a_w$ and moisture content

Water activity ($a_w$) of the snacks was determined according to Machado-Alencar *et al*. (2015), measured at 20°C using an AquaLab (4TE Decagon, USA). For moisture determination, the snacks were dried in a forced convection oven at 105°C until constant weight (AOAC, 1984).

## 2.5 Hardness

Hardness of the samples was determined using TAXT2i texture analyzer (Serial No. 4650, TEE version no. 2.64 UK). A cylindrical probe of 2 mm diameter was used for the measurement of hardness of the samples. The force required for a cylindrical probe to penetrate the sample was measured in Newton (N). Five randomly collected samples of each sample were measured and a mean value was taken as explained by Patras *et al*. (2009).

## 2.6 Color determination

The color of the snacks was determined using the method described by Shittu *et al.* (2009). The histogram of lightness/darkness (L), greenness/ redness (a) and blueness/yellowness (b) color channels of the software (Corel Photo-paint 12) used ranges from -127 to +128 (i.e. L value for Black = 0 to -127 and White = 0 to +127; a value for green = 0 to -127 and red = 0 to +128; b value for blue = 0 to -127 and yellow = 0 to +128). The following equations were used to convert these values to the usual 0 to 100 scale for L* and -100 to +100 scale for a* and b* channels:

$$L = 100 \times L/127 \text{ since L is 0 (lightness)} \quad (1)$$
$$a = 100 \times A/127 \text{ since A is 0 (redness)} \quad (2)$$
$$b = 100 \times B/127 \text{ since B is 0 (yellowness)} \quad (3)$$

L, A and B are the mean values of lightness (L*), redness (a*) and yellowness (b*) color channels (respectively) generated from corel PHOTOPAINT 12 environment (Shittu *et al.*, 2009). The hue angle ($h$°) and browning index (BI) were calculated as follows:

$$h° = \tan^{-1} b/a \quad (4)$$
$$BI = [100 (x - 0.31)] / 0.172 \quad (5)$$

Where

$$x = (a + 1.75L) / (5.645L + a - 3.012b) \quad (6)$$

## 2.7 Chlorophyll content

The snacks were grinded with a mortar and pestle and put into test tube which containing solvent (acetone). The extraction was left for 1 h. Then, the supernatants were collected and measured colorimetrically at 646 nm and 663nm with an UV-VIS spectrophotometer. According to McKinney-Arron relationship chlorophyll content was measured as:

$$\text{Chl a} = 12.21 \times A_{663} - 2.81 \times A_{646}$$
$$\text{Chl b} = 20.13 \times A_{646} - 5.03 \times A_{663}$$
$$\text{Chl total} = 17.32 \times A_{646} + 7.18 \times A_{663}$$

Where Chl a, chlorophyll a, in mg/kg; Chl b, chlorophyll b, in mg/kg; Chl total, total chlorophyll contents, in mg/kg; $A_{663}$, sample absorbance at 663nm; $A_{646}$, sample absorbance at 646 nm.

## 2.8 Statistical analysis

All determinations were performed in triplicate, and results were expressed as the mean ± standard deviation (SD) calculated using spreadsheet software Microsoft Excel. The data were analysed by an analysis of variance ($P \leq 0.05$) and means separated by Duncan's multiple range test. The relationships between the hardness, $a_w$, moisture content, color values and chlorophyll content of the snacks were analysed by Pearson correlation coefficients. The results were processed by SPSS 16.0 (SPSS Inc., Chicago, IL, USA) for Windows.

# 3. Results and Discussion

## 3.1 $a_w$ and moisture content of the snacks from ivy gourd

The $a_w$ values of the raw and fried snacks of all formulae were significantly different ($P \leq 0.05$), which were similar to the moisture result. The result showed that the $a_w$ values of the raw and fried snacks were in the range of 0.382-0.531 and 0.191-0.340, respectively. As well, the moisture contents of the raw and fried snacks were in the range of 6.42-8.37% and 2.20-3.21%, respectively. The $a_w$ values of the raw and fried snacks in descending order were 4% w/v carrageenan >3% w/v carrageenan >2% w/v carrageenan (Figure 2). Increasing concentration of k-carrageenan affected increased $a_w$ values and moisture contents of the raw snacks. The $a_w$ result was similar to the moisture result, showing the relation between two parameters. As an addition, k-carrageenan has a high water-binding characteristic affecting high moisture absorption of the product (Everett and McLeod, 2005). Moreover, availability of free water within carrageenan gel would be increased, thus enhancing $a_w$ value. Tan *et al.* (2018) reported that the effects of hydrocolloids on water-holding capacity and textural properties of noodles were investigated. Xanthan gum (XG), carrageenan (CRG), Arabic gum (AG) and locust bean gum (LBG) were added at 0.5%, 1.0%, 1.5% and 2.0%w/w of flour weight. CRG contributed to significantly (P≤0.05) higher water-holding capacity of dough and firmer texture than XG, AG, LBG. Albeit the insignificant result, the $a_w$ values of the raw and fried snacks of the formulae were lower than the least demanding xerophilic moulds which require around $a_w > 0.6$ to grow (Leong *et al.*, 2011). Therefore, the resulted snacks indicated the ability to prevent most microbial growth.

Nevertheless, the $a_w$ values and moisture contents of the fried snacks were lower than those of the raw snacks (Figure 2). The heating process, namely frying is one of the factors playing a role in decreasing water content. High temperature affects the water content within the products would decrease since most of the existing water are evaporated. Processing with high temperature would cause the water contained in the product to shrink (Akdeniz *et al.*, 2006).

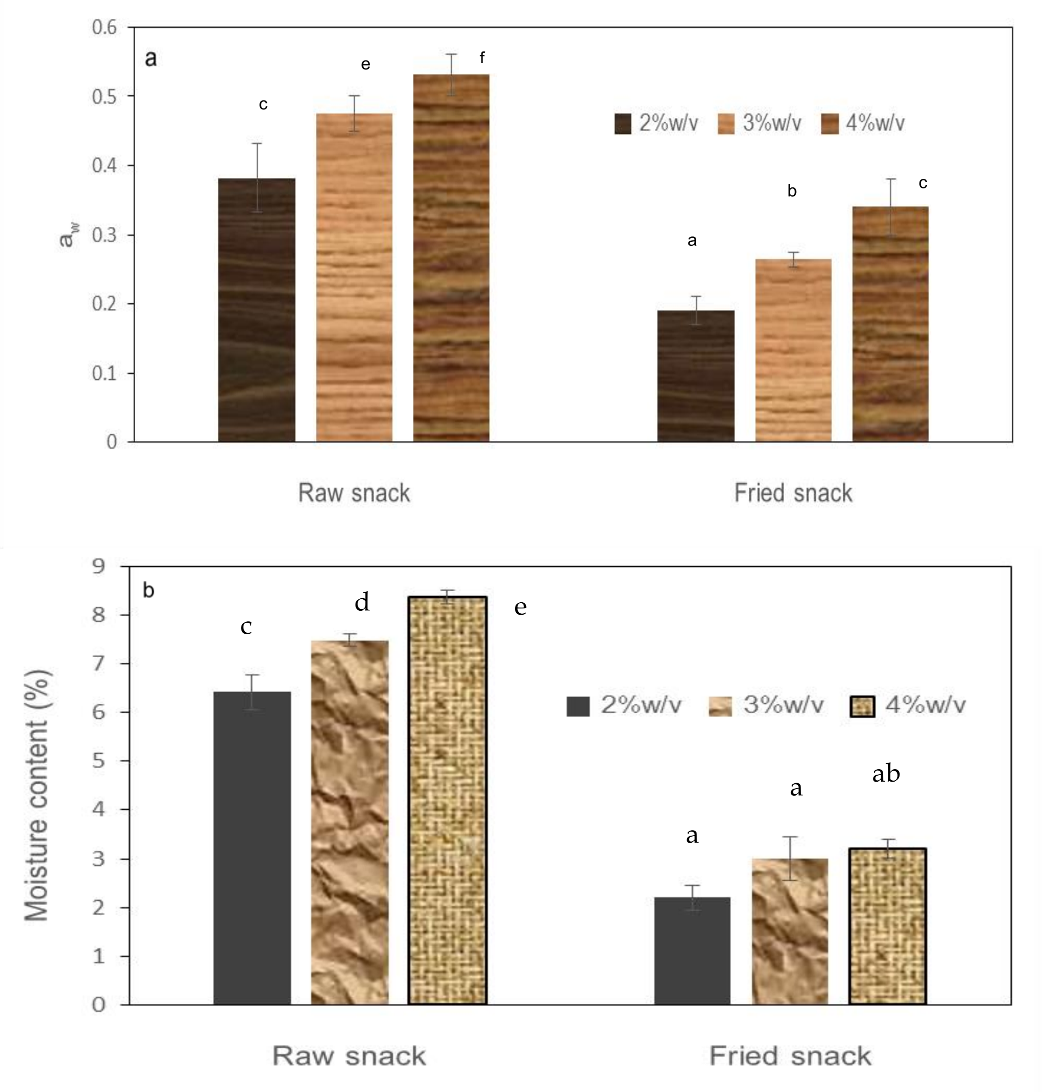


**Figure 2** $a_w$ (a) and moisture content (b) of raw and fried snacks from ivy gourd using 2, 3 and 4%w/v of k-carrageenan. Different letters are significantly different (P≤0.05).

### 3.2 Hardness of the snacks from ivy gourd

The hardness values of the raw and fried snacks were in the range of 4.15-12.86 N and 2.66-4.56 N, respectively. Increasing k-carrageenan concentration affected enhanced hardness of the raw and fried snacks from ivy gourd (P≤0.05). The highest hardness value observed for 4% w/v carrageenan formula of the raw and fried snacks as shown in Figure 3 could be due to increasing concentrations of k-carrageenan showing a greater gel strength (Lai *et al.*, 2000). This result is an agreement with Salvador *et al*. (2005), who reported the addition of gum in the batter formulation increasing hardness of the coating due to the viscosity properties in the gum itself. Higher concentrations of k-carrageenan promote interactions between their chains, which allows a more rigid structure to be formed (Cernikova *et al.*, 2008; Ribeiro *et al.*, 2004). Al-Baarri *et al*. (2018) indicated that the hardness was higher in traditional food models added with k-carrageenan at 2% than the product added I-carrageenan. Therefore, k-carrageenan could be potentially used for producing the snacks based on the hard texture. However, lower contents of k-carrageenan were used in some products, which indicated a suitable network between carrageenan chains to be created. Cernikova *et al*. (2008) reported that the addition of higher concentrations of k-carrageenan in amounts of 0.15% and 0.25% w/w resulted in increased rigidity of processed Eidamsky Blok-Dutch type cheese with different amount of fat.

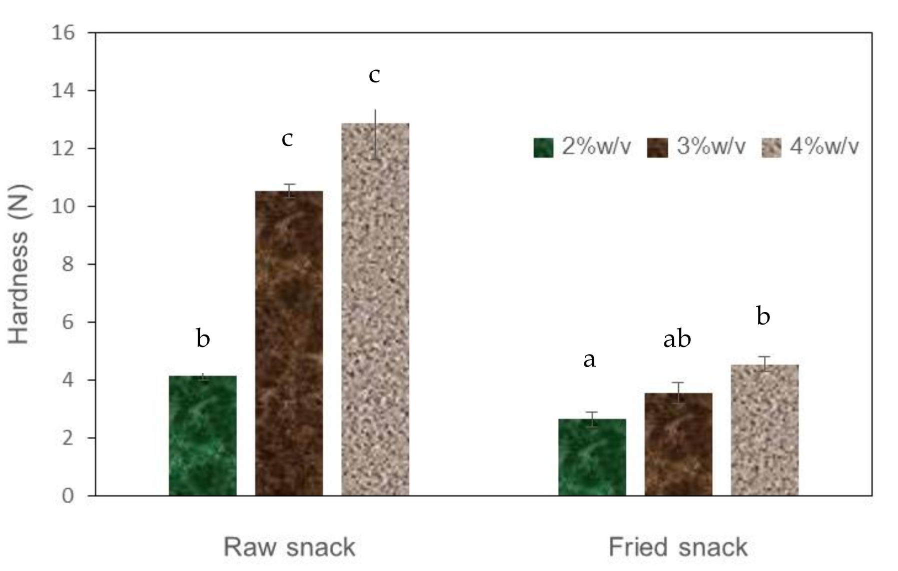


**Figure 3** Hardness (N) of raw and fried snacks from ivy gourd using 2, 3 and 4% w/v of k-carrageenan. Different letters are significantly different (P≤0.05).

Obviously, the hardness values of the fried snacks were lower than those of the raw snacks. This was due to condensation of steam and interfacial tension between the oil and moisture within the pores structure. Higher frying temperature leads to faster moisture loss from the food material (Moreira and Barrufet, 1998). Hence, decreased moisture of the snacks after frying affected the decreased hardness of the products (Figure 3), indicating a crisp characteristic of the snacks.

## 3.3 Color values (L*, $h$°, BI) and chlorophyll contents of the snacks from ivy gourd

Color could be considered as an important attribute, which significantly affects the consumer's perception and determines the nutritional quality of food products during storage (Patras *et al*., 2009). The color parameters of the snacks from ivy gourd using various k-carrageenan concentrations were compared (Table 1). The color parameters were significantly influenced by the addition of different concentrations of k-carrageenan. When k-carrageenan concentration increased, L* values of the raw snacks increased significantly (P≤0.05). The raw snacks added with 4% k-carrageenan showed the highest L* value; whereas, the addition of 2%w/v k-carrageenan to the snacks was highest $h$° and BI values. The increased $L$* value caused due to increase moisture content (or $a_w$) of the snacks with increased k-carrageenan concentration (Figure 2). Akdeniz *et al.* (2006) reported that the ability of gums to bind moisture prevents dehydration and inhibits Maillard and caramelization reactions. Hence, this is a cause to explain the observed higher L* values for the snacks. The L* values and chlorophyll a, b and total chlorophyll contents were found to have lower in the fried snacks than the raw snacks for all the formulae (Table 1 and 2). Changes in the visual color observed on the snacks from ivy gourd (loss of L* and chlorophyll a, b and total chlorophyll) could be mainly related to the conversion of chlorophyll into pheophytin because of heat treatment, as commonly referred for green vegetables (Turkmen *et al*., 2006). Also, the shift of the $h°o$ to blue confirmed that there was a loss in chlorophyll. Funamoto *et al*. (2002) reported that chlorophyll content decreased significantly when treated with high temperature. Similarly, Martinez *et al*. (2001) have examined the influence of temperature on degradation of chlorophyll and the obtained results have indicated the biggest degradation at 35°C. Obviously, in this experiment, the degradation of chlorophyll a, b and chlorophyll total were clearly reduced due to cause of a high frying temperature of 170°C.

Browning index, BI, represents the purity of brown color and is reported as an important parameter in processes where enzymatic and non-enzymatic browning take place (Maskan, 2001). The BI values (ranged from 140.85 to 175.31) increased in all the snacks after frying (Table 1). Color development in the fried snacks resulted in maillard browning and caramelization (Akdeniz *et al*., 2006).

**Table 1** Color values of raw and fried snacks from ivy gourd using 2, 3 and 4% w/v of k-carrageenan

| | Raw snack | | | Fried snack | | |
|---|---|---|---|---|---|---|
| | **2%w/v** | **3%w/v** | **4%w/v** | **2%w/v** | **3%w/v** | **4%w/v** |
| **L*** | 16.83±2.12[a] | 20.46±1.98[b] | 25.94±3.96 | 15.29±1.87[a] | 16.76±2.53[a] | 15.66±0.63[a] |
| **Hue angle ($h$°)** | 185.36±0.22 | 172.25±0.22[b] | 150.44±0.22[a] | 185.22±0.37 | 186.75±0.40 | 189.25±0.48 |
| **Browning index (BI)** | 175.59±0.55 | 165.89±0.60[b] | 140.85±0.79[a] | 175.99±1.19 | 175.70±1.49 | 175.31±1.17 |

**Note:** Means within a row with different superscript are significantly different (P≤0.05)

**Table 2** Chlorophyll a, chlorophyll b, and chlorophyll total of raw and fried snacks from ivy gourd using 2, 3 and 4% w/v of k-carrageenan

| | Raw snack | | | Fried snack | | |
|---|---|---|---|---|---|---|
| | **2% w/v** | **3% w/v** | **4% w/v** | **2% w/v** | **3% w/v** | **4% w/v** |
| **Chl a (mg/kg)** | 12.66±0.02[b] | 16.17±0.02[c] | 20.68±0.08[d] | 4.97±0.01[a] | 4.65±0.03[a] | 4.40±0.02[a] |
| **Chl b (mg/kg)** | 10.90±0.03[b] | 12.80±0.02[c] | 15.14±0.02[d] | 5.25±0.03[a] | 5.07±0.05[a] | 5.75.57±0.05[a] |
| **Chl total (mg/kg)** | 21.05±0.05[b] | 23.96±0.02[c] | 25.82±0.04[d] | 10.22±0.04[a] | 10.71±0.39[a] | 10.98±0.07[a] |

**Note:** Means within a row with different superscript are significantly different ($P \leq 0.05$)

## 3.4 Pearson's correlation coefficients of $a_w$, moisture content, hardness, color values (L*, *h*°, and BI), and chlorophyll a, b, and total chlorophyll in the raw and fried snacks from ivy gourd

The correlation coefficients of $a_w$, moisture content, hardness, color values (L*, *h*°, and BI), and chlorophyll a, b, and chlorophyll total in the raw and fried snacks from ivy gourd are shown in Table 3 and 4. The moisture content was significantly positively correlated with hardness ($r$ = 0.997) and L* ($r$ = 0.979). Moreover, L* was significantly negatively correlated with *h*° ($r$ = -0.954) and BI ($r$ = -0.969), which it was significantly positively correlated with chlorophyll a ($r$ = 0.987), chlorophyll b ($r$ = -0.992), and chlorophyll total ($r$ = -0.938), as well (Table 3). This could clearly support the increased moisture content of the raw snacks as indexing increased hardness and the L*. As well, L* of the raw snacks indicated not only reduced values of h° and BI but also increased values of chlorophyll a, b and total. The hardness of the fried snacks was significantly positively correlated with $a_w$ ($r$ = 0.966) and moisture content ($r$ = 0.998) (Table 4). This indicates that the moisture content could be a good indicator of hardness of the fried snacks.

**Table 3** Pearson's correlation coefficients of aw, moisture content, hardness, color values (L*, *h*°, and BI), and chlorophyll a, b, and total chlorophyll in the raw snacks from ivy gourd

| | $a_w$ | Moisture content | Hardness | L* | *h*° | BI | Chl a | Chl b |
|---|---|---|---|---|---|---|---|---|
| **Moisture content** | 0.998** | | | | | | | |
| **Hardness** | 0.993** | 0.997** | | | | | | |
| **L*** | 0.980* | 0.979* | 0.965* | | | | | |
| ***h*°** | -0.561 | -0.495 | -0.458 | -0.954* | | | | |
| **BI** | -0.448 | -0.775 | -0.455 | -0.969** | 0.997** | | | |
| **Chl a** | 0.888 | 0.878 | 0.798 | 0.987* | -0.997** | -0.997** | | |
| **Chl b** | 0.653 | 0.725 | 0.685 | 0.992** | -0.995** | -0.994** | 0.972* | |
| **Chl total** | 0.772 | 0.652 | 0.777 | 0.938** | -0.989** | -0.999** | 0.991** | 0.988* |

**Table 4** Pearson's correlation coefficients of $a_w$, moisture content, hardness, color values (L*, *h*°, and BI) and chlorophyll a, b, and total chlorophyll in the fried snacks from ivy gourd

| | $a_w$ | Moisture content | Hardness | L* | *h*° | BI | Chl a | Chl b |
|---|---|---|---|---|---|---|---|---|
| **Moisture content** | 0.976* | | | | | | | |
| **Hardness** | 0.966* | 0.998** | | | | | | |
| **L*** | 0.654 | 0.556 | 0.676 | | | | | |
| ***h*°** | 0.496 | 0.322 | -0.528 | -0.325 | | | | |
| **BI** | 0.565 | 0.365 | 0.525 | -0.478 | 0.714 | | | |
| **Chl a** | 0.569 | 0.595 | 0.258 | 0.799 | -0.725 | -0.696 | | |
| **Chl b** | 0.465 | 0.332 | 0.568 | 0.756 | -0.666 | -0.625 | 0.844 | |
| **Chl total** | 0.580 | 0.325 | 0.458 | 0.814 | -0.758 | -0.772 | 0.769 | 0.749 |

## 4. Conclusion

The effect of addition of various k-carrageenan concentrations on some characteristics of the raw and fried snacks from ivy gourd was studied. The increased values of moisture content, hardness and $a_w$ of the raw and fried snacks caused due to increase k-carrageenan concentration. The optimal concentration of k-carrageenan was 4% w/v since the L* value and chlorophyll a, chlorophyll b and total chlorophyll contents of raw snacks using that concentration were higher than those of raw snacks using other concentrations. However, *h*° and BI values of raw snacks using that concentration were lower than of raw snacks using other concentrations. Moreover, the increased L* value of the raw snacks was a good index for the increased chlorophyll a, chlorophyll b and total chlorophyll, but except using an index after frying. Thus, the experimental results show the optimal concentration of k-carrageenan could be developed to upscale the production process of snacks from ivy gourd with great nutritional value at low cost.

## Acknowledgements

Authors thank Rajamangala University of Technology Krungthep for maintenance and operation of the scientific laboratory and equipments.

## References

Akdeniz, N., Sahin, S. and Sumnu, G. 2006. Functionality of batters containing different gums for deep-fat frying of carrot slices. Journal of Food Engineering. 75(4): 522-526.

Al-Baarri, A.N., Legowo, A.M, Rizqiati, H., Septianingrum, A., Sabrina, H.N., Arganis, L.M., Saraswati, R.O. and Mochtar, Rr.C.P.R. 2018. Application of iota and kappa carrageenans to traditional several food using modified cassava flour. IOP Conference Series: Earth and Environmental Science. 102(1): 012056.

Alimi, B.A., Shittu, T.A., Sanni, L.O. and Arowolo, T.A. 2013. Effect of some hydrocolloids as adjuncts on the quality of whole egg or egg white coated fried yam chips. Journal of Food, Agriculture and Environment. 11: 19-24.

AOAC. 1984. Official Methods of Analysis of the Association of Official Analytical Chemists, 14th edn. AOAC, Arlington, VA.

Bosc, V., Ferrari, I. and Michon, C. 2008. Adhesion to solid surfaces of gels of iota-carrageenan Alone or in mixture with casein. Colloids and Surfaces A: Physicochemical and Engineering Aspects. 331(1-2): 2-7.

Cernikova, M., Bunka, F., Pavlinek, V., Brezina, P., Hrabe, J. and Valasek, P. 2008. Effect of carrageenan type on viscoelatic properties of precessed cheese. Food Hydrocolloids. 22: 1054-1061.

Chatage, V.S. and Bhale, U.N. 2012. Mineral contents changes due to fruit rot fungal pathogens of ivy gourd (*Coccinia indica* Wight and Arn.). International Journal of Pharmacy and Biological Sciences. 2(4): 262-265.

Dam, R.M. and Seidell, J.C. 2007. Carbohydrate intake and obesity. European Journal of Clinical Nutrition. 61: S75-S99.

Deen, B. and Singh, I.S. 2013. Studies on preparation and storage of jelly from karonda (*Carissa carandas* L.) fruits. Beverage and Food World. 40: 60-64.

Everett, D.W. and McLeod, R.E. 2005. Interactions of polysaccharide stabilizers with casein aggregates in stirred skim-milk yoghurt. International Dairy Journal. 15(11): 1175-1183.

Funamoto, Y., Yamauchi, N., Shigenaga, T. and Shigyo, M. 2002. Effects of heat treatment on chlorophyll degrading enzymes in stored broccoli (*Brassica oleracea* L.). Postharvest Biology and Technology. 24(2): 163-170.

Hossen, S., Kabir, M.S., Uddin, M.B., Rahman, A.K.M.L. and Mamun, M.R.A. 2009. Effect of different extra ctions of juice on quality and acceptability of guava jelly. Journal of Innovation and Development Strategy. 3(4): 27-35.

Hunt, A. and Park, J.W. 2013. Alaska pollock fish protein gels as affected by refined carrageenan and various salts. Journal of Food Quality. 36(1): 51-58.

Kuchi, V.S., Gupta, R. and Tamang, S. 2014. Standardization of recipe for preparation of guava jelly bar. Journal of Crop and Weed. 10(2): 77-81.

Lai, V.M.F., Wong, P.A.L. and Lii, C.Y. 2000. Effects of cation properties on sol-gel transitionand gel properties of k-carrageenan. Journal of food science. 65(8): 1332-1337.

Lascombes, C., Agoda-Tandjawa. G., Boulenguer, P., Garnec, C.L., Gilles, M., Barey, P. and Langendorff, V. 2016. Starch-carrageenan interactions in aqueous media: role of each polysaccharide chemical and macromolecular characteristics. Food Hydrocolloids. 66: 176-189.

Leong, S.L.L., Pettersson, O.V., Rice,T., Hocking, A.D. and Schnurer, J. 2011. The extreme xerophilic mould *Xeromyces bisporus*-Growth and competition at various water activities. International Journal of Food Microbiology. 145(1): 57-63.

Machado-Alencar, N.M., Steel, C.J., Alvim, I.D., Carvalho de Morais, E. and Andre-Bolini, H.M. 2015. Addition of quinoa and amaranth flour in gluten-free breads: Temporal profile and instrumental analysis. LWT-Food Science and Technology. 62(2): 1011-1018.

Martinez, G.A., Civello, P.M., Chaves, A.R. and Anon, M.C. 2001. Characterization of peroxidase-mediated chlorophyll bleaching in strawberry fruit. Phytochemistry. 58(3): 379-387.

Maskan, M. 2001. Kinetics of colour change of kiwifruits during hot air and microwave drying. Journal of Food Engineering. 48(2): 169-175.

Moreira, R.G. and Barrufet, M.A. 1998. A new approach to describe oil absorption in fried foods: a simulation study. Journal of Food Engineering. 35(1): 1-22.

Murti, T.P., Purnomo, A.H., Dharmayanti, N. and Salampessy, R.B.S. 2019. Application of refined carrageenan (RC) in the non-gluten crispy fish seaweed product processing. IOP Conference Series: Earth and Environmental Science. 278(1): 012048.

Panchal, J.B., Gaikwad, R.S., Dhemre, J.K. and Chavan, U.D. 2018. Studies on preparation and storage of jelly from dragon fruit (*Hylocereus undatus*). Journal of Pharmacognosy and Phytochemistry. 7(4): 2648-2655.

Patras, A., Brunton, N.P., Tiwari, B.K. and Butler, F. 2009. Stability and degradation kinetics of bioactive compounds and colour in strawberry jam during storage. Food and Bioprocess Technology. 4: 1245-1252.

Ribeiro, K.O., Rodrigues, M.I., Sabadini, E. and Cunha, R.L. 2004. Mechanical properties of acid sodium caseinatek-carrageenan gels: Effect of co-solute addition. Food Hydrocolloids. 18(1): 71-79.

Salvador, A., Sanz, T. and Fiszman, S.M. 2005. Effect of addition of different ingredients on the characteristics of batter coating for fried seafood prepared without a pre-frying step. Food Hydrocolloids. 19(4): 703-708.

Shittu, T.A., Aminu, R.A. and Abulude, E.O. 2009. Functional effects of xanthan gum on composite cassava-wheat dough and bread. Food Hydrocolloids. 23(8): 2254-2260.

Singh, J. and Chandra, S. 2012. Preparation and evaluation of guava-carrot jelly. International Journal of Food and Fermentation Technology. 2(2): 197-200.

Tan, H.L., Tan, T.C. and Easa, A.M. 2018. The use of selected hydrocolloids to enhance cooking quality and hardness of zero-salt noodles. International Journal of Food Science and Technology. 53(7): 1603-1610.

Turkmen, N., Poyrazoglu, E.S., Sari, F. and Velioglu, Y.S. 2006. Effects of cooking methods on chlorophylls, pheophytins and colour of selected green vegetables. International Journal of Food Science and Technology. 41(3): 281-288.