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Effect of egg albumin concentration and carboxymethyl cellulose on properties of *hom-thong* banana [*Musa acuminata* (AAA group) 'Gros Michel'] foam snack produced by foam mat drying

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Abstract

The present work aimed to develop a dried *hom-thong* banana foam snack by incorporating egg albumin (EA) and carboxymethyl cellulose (CMC) for foam formation, followed by air drying, offering a technological alternative for the banana pulp. The effect of EA at different concentrations (5, 7.5, and 10%), incorporated without or with the addition of CMC (0 or 0.15%) into the mixture of banana foam (w/w), on its foam properties as well as the characteristics of the snacks, was investigated. An increase in the concentration of EA from 5% up to 7.5% resulted in an increase in foaming ability with foam expansion (400.50 - 535.19%), because entrapping air in the foam was limited at a maximum concentration of 7.5% EA. However, the addition of 0.15% CMC into the mixture of banana foam containing 10% EA (10% EA + 0.15% CMC) presented the highest foam expansion (641.62%), the lowest density (0.22 g/mL), and excellent foam stability estimated from without foam drainage. Moisture content and water activity (a_w) of all banana foam snacks were low (5.08 - 7.84%) after air drying at 75°C for 6 h, and the maximum a_w value was less than 0.6 (0.18 - 0.25), ensuring the microbiological stability of the product at ambient temperature. When applying EA at a concentration of 5% and adding 0.15% CMC (5% EA + 0.15% CMC), the snack had high structure stability and was crispy, as its hardness and fracture force were 10.28 and 8.37 N, respectively, and a low colour negative appearance resulting from a lower browning index (BI) was found. This sample also received a high score for the sensory evaluation of appearance and overall acceptance. In comparison to the 10% EA sample, although the 5% EA + 0.15% CMC sample had lower trend for some sensory scores, its texture properties, colour, and BI values were superior. Therefore, to produce a dried banana foam snack using foam mat drying, applying EA at a concentration of 5% in addition of 0.15% CMC is recommended.

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Introduction

Bananas are consumed globally due to their being inexpensive and affordable for nearly everyone (Rodriguez-Amaya, 2010; Al Amri and Hossain, 2018). Banana pulp is the edible portion of the fruit, and rich in carbohydrates and minerals such as phosphorus, potassium, calcium, and a high vitamins A and C (Sidhu and Zafar, 2018). Most fruits have high moisture content, and are highly perishable. Food processing or preservation is a process in which perishable foods, such as fruits and vegetables, are converted into stabilised food products that can be maintained for a prolonged time to minimise their postharvest losses (Kiaya, 2014).

Drying is one of the methods required for producing newer, acceptable, and excellent edible foods. Commercially, dried products from fruits and vegetables are processed into flour, flakes, granulated preparations, powders, and additional ingredients of ready to-eat soups, salads, energy bars, cereals, and snacks (Martínez *et al.*, 2024). There are several studies on banana pulp drying using various methods, *e.g.*, sun drying, solar drying, oven drying, and freeze drying. Freeze drying is considered among the best drying methods because it provides high-quality dried

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products and minimal chemical changes, and the freeze-dried products' organoleptic properties once rehydrated are almost the same as those of the fresh products (Abbasi and Azari, 2009; Naknaen *et al*., 2016). Its disadvantage is that it is an expensive method with high production costs, which limits its wide utilisation by the food manufacturing (Martínez *et al*., 2024). On the other hand, sun drying is a traditional method which involves the sunlight to dry food products, and requires large surface areas of exposure to facilitate moisture migration throughout the tissues, and evaporation of moisture from the surface. Bananas to be dried are left exposed to the sun for several days to achieve the desired moisture content. Additionally, sun-dried bananas usually have low quality as they are often contaminated by insects, dust, dirt, pests, and microorganisms. Solar drying is not only a faster, cleaner, and more efficient method compared to the open sun drying, it also provides higher quality products by maintaining the nutrient levels of the fruits, with reduced drying time compared to natural sun drying (Lingayat *et al*., 2017; Nabnean and Nimnuan, 2020). Hot air drying is carried out on perforated trays or racked carts in oven dryers. The hot air passes through the banana, and exits from the dryer continuously during the process, which can be controlled, and moisture is removed effectively (Brennan and Grandison, 2012; Martínez *et al*., 2024). However, the drying of banana can cause changes in qualities, such as colour, shrinkage and porosity, and texture. Additionally, type of drying method also affects the physicochemical and nutritional properties of the banana products (Martínez *et al*., 2024).

Foam mat drying is one of the most economical and efficient drying techniques, in which liquid or semisolid food materials are converted into stable foam through whipping, along with the addition of foaming and stabilising agents, and then air dried (Kandasamy *et al*., 2012; Franco *et al*., 2016; Günaydin *et al*., 2024). This foam is air-dried at a temperature ranging from 50 to 80°C (Kandasamy *et al*., 2012). Compared to other drying processes, this technique offers many advantages which include accelerated drying at lower drying temperatures, low-energy usage, shorter drying times, and low cost (Febrianto *et al*., 2012). The increase in the surface area in contact with the air increases the water removal speed, leading to less time for drying and retainment of product quality (Dehghannya *et al*., 2018). It also preserves the nutrients and sensory quality of food products that are lost during other drying methods (Kadam *et al*., 2010; Zhang *et al*., 2017). Furthermore, foam mat drying also adds value to the food material, reduces microbial activity, and protects against degradation reactions of the product (Kudra and Ratti, 2006). Over the years, this process has been applied to many fruits, *i.e*., banana (Thuwapanichayanan *et al*., 2012), cherry (Abbasi and Azizpour, 2016), pineapple (Shaari *et al*., 2018), and plum (Sifat *et al*., 2021). To proceed, fruits like banana pulps need a foaming agent such as egg white protein, soy protein isolate, and whey protein concentrate incorporated to be whipped for the formation of foams (Thuwapanichayanan *et al*., 2012). Egg white protein (or egg albumin) is widely used to form a cohesive viscoelastic film *via* interactions between different molecules of proteins, and has adsorption capacity at the air-water interface during the whipping (Mine, 1995; Lomakina and Mikova, 2006). Carboxymethyl cellulose (CMC) is a cellulose derivative that also has many roles such as being a suspending agent, thickener or viscosity modifier, emulsifier, and stabiliser in food products (Tabari, 2017). Several works have reported that dried albumen is an excellent foaming agent for bananas. However, the fruit foams produced by this foaming agent were quite unstable due to it involving the type of foaming agent and foam stabiliser, as well as their concentrations (Kandasamy *et al*., 2012; Thuwapanichayanan *et al*., 2012; Hossain *et al*., 2021).

Since there has been little information on the production of dried foamed banana as a snack product using foam mat drying, the present work aimed to develop a dried product as banana foam snack by incorporating egg albumin (EA) and carboxymethyl cellulose (CMC) for foam formation, followed by air drying, offering a technological alternative for the banana pulp.

Materials and methods

Materials

Fully ripe *hom-thong* banana (*Musa acuminata*, AAA group, *Gros Michel* subgroup, cultivar Hom-Thong) samples were harvested at a mature stage of 6 according to Sripaurya *et al*. (2021), and yellow with brown flecks (if the fruit is too ripe, it has a short remaining lifespan). The samples were obtained from Waiwhan Community Enterprise in Phetchaburi Province (Thailand).

The total soluble solid of the banana pulp was approximately 22 - 25 °Brix, measured using a digital hand-held refractometer (Atago, Model PAL-1, Japan). Hen egg albumin (EA) powder was obtained from B.V. Nederlandse Industrie Van Eiproducten Co. Ltd., Nunspeet (Netherlands), and both carboxymethyl cellulose (CMC) and citric acid were purchased from Krungthepchemi Co. Ltd., Bangkok (Thailand).

Preparation of banana foams

Banana pulp was cut into pieces (1 cm thickness) using a knife. The sliced bananas were pretreated by immersion in 1% (w/w) citric acid solution for 10 min to inhibit browning by reducing the pH, which disrupts the enzymatic activity responsible for discoloration, and by limiting oxygen contact during the fresh-cut preparation (Sakdadech *et al*., 2021). Rinsing twice with drinking water was applied to reduce the sour taste of the banana pulp, followed by blanching them in hot water (80°C) for 5 min. This effectively inactivated the enzymatic browning reaction by denaturing the proteins that constitute the enzymes (Yap *et al*., 2017), which in turn improved the drying rates due to cell wall destruction and structure softening, and lowering the resistance to vapour movement during drying, thus reducing the drying time and energy consumption (Dandamrongrak *et al*., 2003; Prachayawarakorn *et al*., 2016). Subsequently, they were cooled with cold water for 5 min (modified from Naknaen *et al*., 2016). After that, the pretreated banana pieces were whipped in a blender (Panasonic, Model MX-AC400, India) for 1 min to obtain banana purée. To prepare 400 g of each batch, the banana purée was weighed using a precision balance (Bel Engineering, Model ES2202, Italy), poured into a mixing bowl, and EA was added as the foaming agent at concentrations of 5, 7.5, and 10% (w/w, based on a wet basis) according to different banana foam formulations per 100 g listed in Table 1. The mixtures of banana purée and EA were continuously whipped using a mixer (Kitchen Aid, Model Artisan 5KSM150, USA) at half speed for 15 min, followed by subsequent mixing without or with CMC at a concentration of 0.15% (w/w) for 5 min, as shown in Figure 1.

Table 1. Formulations of banana foams produced by different concentrations of egg albumin (EA), without and with carboxymethyl cellulose (CMC).

Formulation	Ingredient (%)			
	Banana	**Water**	**EA**	**CMC**
5% EA	90	5	5	0
7.5% EA	87.5	5	7.5	0
10% EA	85	5	10	0
5% EA + 0.15% CMC	90	4.85	5	0.15
7.5% EA + 0.15% CMC	87.5	4.85	7.5	0.15
10% EA + 0.15% CMC	85	4.85	10	0.15

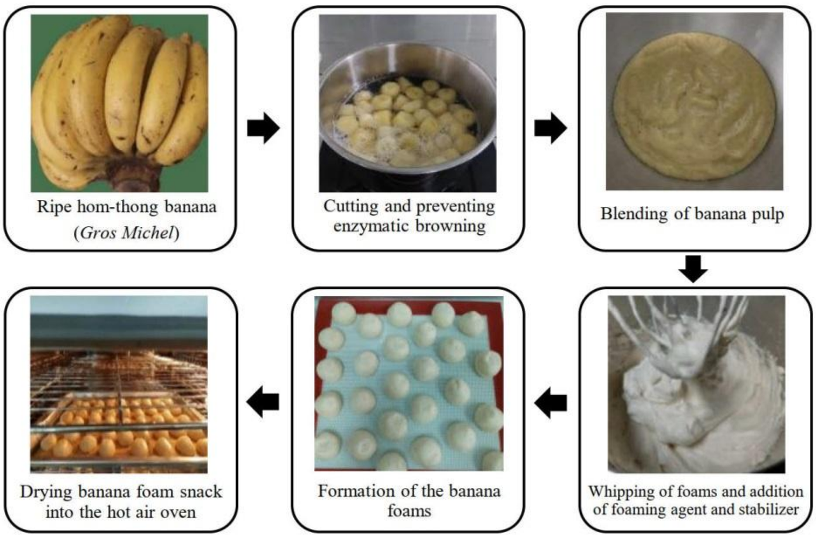

Figure 1. Flow diagram of banana foam and dried banana foam snack preparation.

Drying of banana foam snack

The banana foams were extruded and placed on a silicone sheet using a round piping tip with a round shape (2.5 cm diameter, 1.0 cm thickness). To achieve sufficiently low moisture content (<15%, wet basis) and water activity (<0.6 a_w), which are the two most critical parameters regarding food safety and quality preservation of dried products (Barbosa-Cánovas, 2003), the foams of all samples were dried at 75°C with an air velocity range of 0.6 - 1.6 m/s for 6 h after the temperature reached the target temperature using a hot air oven (France-Etuves, Model XU490, France), as shown in Figure 1.

Determination of banana foam properties

Foam density

The density of banana foam was measured according to Watharkar *et al*. (2021). Briefly, 500 mL of foamed banana was gently poured in a pre-weighed measuring container with a precision balance (BEL Engineering, Model ES2202, Italy) at ambient temperature. The mass of banana foam with respect to volume was recorded after each measurement. The density of banana foam was calculated with three replicates using Eq. 1:

$$\text{Foam density (g/mL)} = m / V \qquad \text{(Eq. 1)}$$

where, m = mass of banana foam in g, and V = volume of banana foam in mL.

Foam expansion

The foam expansion of banana pulp was measured according to Veerapandian *et al*. (2015). Foam expansion represents the volume of air assimilated into the banana purée during foaming. The initial (before foaming) and final (after foaming) volumes of purée were measured in three replicates, and the foam expansion was calculated using Eq. 2:

$$\text{Foam expansion (\%)} = [(V_1 - V_0) / V_0] \times 100 \qquad \text{(Eq. 2)}$$

where, V_0 = initial volume of banana purée in mL, and V_1 = final volume of banana purée in mL.

Drainage volume

The drainage volume of banana foam was measured according to Bag *et al*. (2011) with a slight modification. Initially, the foam was filled into a glass funnel (80 mm diameter), and placed over a 25-mL measuring cylinder at 27 ± 1°C. The amount of liquid drained through the funnel was collected up to 2 h. The mean value of three measurements was considered the drainage volume.

Determination of quality characteristics of banana foam snacks

Moisture content

Moisture content was determined following the procedures of the Association of Official Analytical Chemists method 930.04 (AOAC, 2005). Five grams of the sample was weighed using an analytical balance (Shimadzu, Model ATX224, Japan), and dried at 105°C to constant weight using a hot air oven (France-Etuves, Model XU490, France). The loss in weight was determined to calculate the percent moisture content.

Water activity

The water activity (a_w) of 2 g sample was measured using a water activity meter (Aqualab, Model Series 3TE, USA).

Colours and browning index

The colour properties of the banana foam snacks were determined using a spectrophotometer (3NH, Model YS3010, China). The calibration of the device was performed using a white and black calibration plate prior to measurement. The colours were recorded with a mode of CIE (Young and Whittle, 1985) in terms of L^* value (lightness), where 0 indicates darkness (0) and 100 brightness; a^* value, indicated by greenness ($-a^*$) or redness ($+a^*$); and b^* value, indicated by blueness ($-b^*$) or yellowness ($+b^*$) of the snack. The browning index (BI), as described by Nasser *et al*. (2017), was calculated using Eqs. 3 and 4:

$$BI = [100 (x - 0.31) / 0.17] \qquad \text{(Eq. 3)}$$

$$\text{where, } x = (a^* + 1.75L^*) / (5.645L^* + a - 3.012b^*) \qquad \text{(Eq. 4)}$$

Textural characteristics and sensory acceptability

Texture characterisation of banana foam snack was performed at ambient temperature using a texture analyser (Stable Micro Systems, Model TA.XT. plus, UK) and applying a three-point bending rig (HDP/3PB) for the test sample. Parameters used for the test were: pre-test speed and test speed, 2.0 mm/s; post-test speed, 10 mm/s; depression distance, 10 mm; and trigger force, 5 g. The highest value of force required to compress the sample during the first compression was measured as hardness (N), and the fracture force value (N) at the first peak of the first compression when the sample broke was measured as fracturability (Bianchi *et al*., 2016).

The sensory acceptability of the banana foam snack (appearance, colour, flavour, taste, oral crispness, and overall acceptability) was evaluated by a panel of 30 judges using a 9-point hedonic scale scoring (9 = extremely like, and 1 = extremely dislike). The panellists included male and female members (age between 20 and 60 years) of the Faculty of Science and Technology at Rajamangala University of Technology Krungthep (Bangkok, Thailand).

Statistical analysis

A one-way analysis of variance (ANOVA) was applied to investigate the differences between formulations. Each experimental analysis of characteristics was performed in three replicates (n = 3), except the sensory acceptability, which was tested with 30 replicates (n = 30), in which the mean values with standard deviations were expressed. To test the differences between mean values, Duncan's new multiple range test (DMRT) was adopted using the SPSS statistic program (trial version) *via* www.ibm.com, and the significance was defined at the level of 5%.

Results and discussion

Foam properties of hom-thong banana foam

The results presented in Figure 2 show that increasing the amount of foaming agent containing 0.15% CMC leads to an increase in foam expansion, and a decrease in foam density. Statistically, the foam expansion significantly varied from 384.76 to 641.62%, depending on EA concentration, with the highest expansion was found in the sample with the highest EA concentration in foam being CMC (10% EA + 0.15% CMC), as indicated in Figure 2a. For this sample, the foam density of the foam mixture was found to be the lowest (0.22 g/mL) in comparison to others (0.26 - 0.28 g/mL), as shown in Figure 2b.

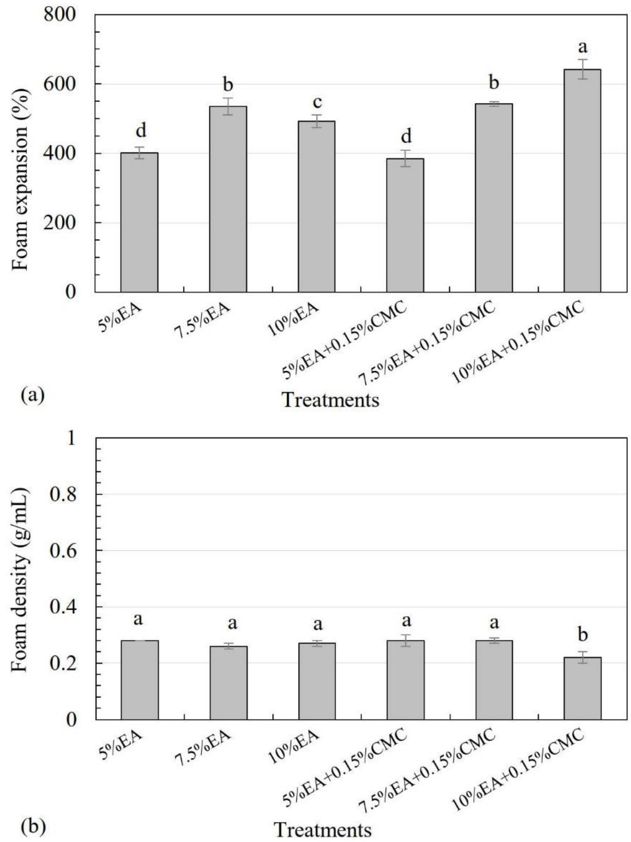

Figure 2. Foam expansion **(a)** and foaming density **(b)** of banana foams produced by different concentrations of egg albumin (EA), without and with carboxymethyl cellulose (CMC). Different lowercase letters indicate significant differences between treatments ($p < 0.05$).

The slight decreasing trend in foam density with increasing concentrations of EA to reaching a concentration of up to 7.5% incorporation without the addition of 0.15% CMC (7.5% EA) indicated that the amount of air being entrapped in the foam had limits. This result might have been due to the insufficient surface tension reduction which enhanced the foam formation (Thuwapanichayanan *et al*., 2008). Remarkably, the increase in EA concentration incorporating 0.15% CMC contributed to a strong increase in foaming ability.

In an earlier work by Shaari *et al.* (2018), the different concentrations (5, 10, and 20%, w/w) of EA applied as a foaming agent significantly affected the foaming properties of dried pineapple powder. Such an increase in the amount of EA led to a considerable increase in foam expansion, and a decrease in foam density. Similar result was also reported by Sifat *et al*. (2021), who found that the foam density substantially decreased with the increased concentrations of EA

(2, 4, and 6%, w/w) added as a foaming agent for plum foam. Interestingly, a moderate EA concentration (4%) with a whipping time of 10 - 15 min was found the best possible condition that facilitates effective drying and thermal conductivity for economical drying. Thuwapanichayanan *et al.* (2012) also reported that applying EA at a concentration of 5% (w/w) could produce a banana foam density of 0.3 g/mL with a whipping duration of 20 min, which was enough for the foaming purpose.

Foam stability is the water-holding capacity of the foam, and relates to the rate at which the liquid drains from it (Kampf *et al*., 2003). Therefore, measuring the drainage volume of foam is one of the better methods for the determination of foam stability (Bag *et al*., 2011). In the present work, the drainage volume of all banana foams was observed at 100% of certain volume in comparison to the foams, and the addition of 0.15% CMC did not negatively influence the foam stability ($p \geq 0.05$). The data indicated that EA applied for its protein ability to form a thick film around air bubbles had an impact on the sufficient retention of incorporated gases, resulting in stability on surface tension (Lomakina and Mikova, 2006).

Quality characteristics of dried banana foam snack

After drying foam bananas using a hot air oven (France-Etuves, Model XU490, France) 75°C for 6 h, all dried products were then analysed and observed as follows:

Moisture content and water activity

Moisture content and water activity are the two most important criteria influencing food safety and quality preservation of dried products (Ozcelik *et al*., 2020). The water content of dried fruits such as bananas should be less than 15% (wet basis), and water activity should be less than 0.6 a_w to ensure that the product would have high microbiological stability at ambient temperature (Barbosa-Cánovas, 2003).

As shown in Table 2, a notable decrease in moisture content of the dried banana foam snack is apparent, ranging from 5.08 to 7.84% on a wet basis with increasing EA ($p < 0.05$). Additionally, the water activity values ranged from 0.18 to 0.25 a_w ($p < 0.05$). This suggested that the a_w value for all samples was below the critical value (0.6 a_w), thus ensuring microbiological stability of the dried banana foam snack at ambient temperature.

Table 2. Moisture contents and water activities of dried banana foam snacks produced by different concentrations of egg albumin (EA), without and with carboxymethyl cellulose (CMC).

Formulation	Moisture content	Water activity
5% EA	7.84 ± 0.17^{a}	0.20 ± 0.00^{bc}
7.5% EA	6.50 ± 0.11^{c}	0.20 ± 0.01^{bc}
10% EA	5.08 ± 0.05^{e}	0.22 ± 0.01^{b}
5% EA + 0.15% CMC	7.22 ± 0.19^{b}	0.18 ± 0.02^{c}
7.5% EA + 0.15% CMC	6.12 ± 0.28^{d}	0.23 ± 0.00^{b}
10% EA + 0.15% CMC	6.22 ± 0.17^{cd}	0.25 ± 0.01^{a}

Means followed by different lowercase superscripts in similar column are significantly different between treatments ($p < 0.05$).

In a previous study on dried foam-mat products determined by Noordia *et al*. (2020), banana foam made into powder through the foam-mat drying method using a combination of ripe banana pulp (*kapok*, *ambon*, and *agung*) was stabilised with 3% EA. It was found that the final moisture content for the foam mat dried banana flour was the lowest at 11.15%.

Colour parameters and browning index (BI)

As shown in Table 3, the L^* value was significantly higher ($p < 0.05$) for dried banana foam snack produced from banana pulp using EA at a concentration of 5% as a foaming agent in addition of 0.15% CMC (5% EA + 0.15% CMC) as a foam stabiliser (L^* value = 71.02), in comparison to other samples (64.41 to 69.39). The colour parameters of a^* and b^* ranged between values 2.66 to 4.26 and 20.83 to 25.69, respectively, for all samples. The results indicated that the visual colour appearance of dried banana foamed snacks was a light yellowish to golden-brown tone with increasing concentrations of EA. However, for the treatments with varied concentrations of EA in the addition of CMC, the

Table 3. Colour parameter values and browning index (BI) of dried banana foam snacks produced by different concentrations of egg albumin (EA), without and with carboxymethyl cellulose (CMC).

Formulation	Colour parameter			Browning index
	*L**	*a**	*b**	
5% EA	69.39 ± 0.40^{b}	4.26 ± 0.06^{a}	23.89 ± 0.44^{c}	45.85 ± 0.63^{c}
7.5% EA	68.57 ± 0.63^{b}	4.24 ± 0.02^{a}	23.79 ± 0.37^{c}	46.26 ± 0.64^{c}
10% EA	65.11 ± 0.47^{d}	4.15 ± 0.10^{a}	25.69 ± 0.34^{a}	53.69 ± 0.29^{a}
5% EA + 0.15% CMC	71.02 ± 0.30^{a}	3.07 ± 0.13^{b}	21.72 ± 0.19^{d}	38.93 ± 0.43^{e}
7.5% EA + 0.15% CMC	64.41 ± 0.46^{d}	2.66 ± 0.06^{c}	20.83 ± 0.20^{e}	41.27 ± 0.51^{d}
10% EA + 0.15% CMC	66.40 ± 0.53^{c}	2.82 ± 0.08^{c}	24.74 ± 0.62^{b}	48.63 ± 1.80^{b}

Means followed by different lowercase superscripts in similar column are significantly different between treatments ($p < 0.05$).

average values of a^* and b^* for the snack were significantly lower in comparison with the treatments at the same concentration of EA ($p < 0.05$).

The browning index (BI) increased from 45.85 to 53.69 for samples incorporating EA and 0.15% CMC, while another group had comparatively lower values of 38.93 to 48.63 when increasing the concentration of EA (5, 7.5, and 10%). Asfi *et al.* (2017) supported this result, noted that the presence of EA could accelerate the Maillard reaction during the heating process; non-enzymatic browning reaction between glucose (carbohydrates) and amino groups (proteins) that occurs at high temperatures can make brown colour.

As shown in Table 3, the addition of 0.15% CMC into the samples could act as a foam stabiliser due to it having a hydrophilic structure, which can contribute to the reduction of humidity of the mixture, and subsequently affect the Maillard reaction during the drying process (Abbasi and Azizpour, 2016) to reduce the brown colour development.

Textural characteristics and sensorial acceptance

Figure 3 shows the textural properties of dried banana foam snacks produced *via* the foam mat drying method with varying concentrations of EA and the addition of 0.15% CMC into banana foam, which strongly affected the textural properties. The snacks with no addition of 0.15% CMC had less hardness and fracturability (crispness) than those with 0.15% CMC, as shown in Figures 3a and 3b, respectively.

For hardness, the dried banana foam snacks with the addition of 0.15% CMC were characterised by a significantly higher values of hardness (10.28 to 13.87 N) than those without the addition of 0.15% CMC (3.78 to 8.09 N), as shown in Figure 3a. This indicated that the concentration of EA and the addition of 0.15% CMC exerted significant influence on hardness, which is defined as the resistance of external loads and forces (Bourne, 2002).

In terms of fracturability (sometimes called brittleness or crispness), as shown in Figure 3b, the

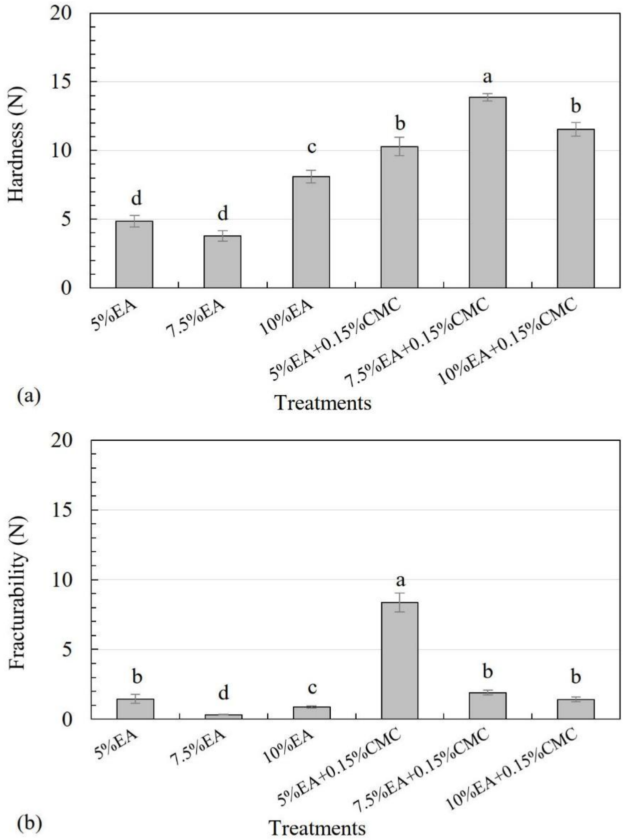

Figure 3. Hardness **(a)** and fracturability **(b)** of dried foamed banana snacks produced by different concentrations of egg albumin (EA), without and with carboxymethyl cellulose (CMC). Different lowercase letters indicate significant differences between treatments ($p < 0.05$).

highest value was obtained in the sample produced with EA at a concentration of 5% and the addition of 0.15% CMC (8.37 ± 0.68 N), and the lowest value was observed in the sample produced with EA at a concentration of 7.5% (0.33 ± 0.02 N) ($p < 0.05$). Szczesniak (1963) defines the attribute of fracturability as the force required to break the sample (crumbles, cracks, or shatters). The addition of 0.15% CMC showed a significantly higher fracture force by promoting crispiness for the samples. This could have been due to the characteristics of CMC for various application purposes that can be defined by properties such as rheology, viscosity, and fracture behaviour (Rahman *et al*., 2021).

The visual appearances of the dried banana foam snacks corresponding to the six different formulations (Table 1) are shown in Figure 4a, and their sensory features determined using a 1 to 9-point hedonic scale test for appearance, colour, flavour, taste, oral crispness, and overall acceptance are shown in Figure 4b.

It was found that the snacks produced from banana foams using EA at a concentration of 5% and 0.15% CMC (5% EA + 0.15% CMC), and using EA at the concentration of 10% (10% EA), received higher scores, differing significantly from the others with a minimum score of 7.0, which corresponded to "like moderately" for appearance and overall acceptance evaluation. The sample produced using EA at the concentration of 10% (10% EA) also showed a significantly higher acceptance for taste and crispness, with the highest scores of above 7.3, which corresponded to "like moderately" (Figure 4b).

The dried banana foam snack produced by a foam-mat process using EA at a concentration of 5% EA and 0.15% CMC (5% EA + 0.15% CMC) and using EA at the concentration of 10% (10% EA) received higher scores for the characteristics of appearance and overall acceptance than other samples.

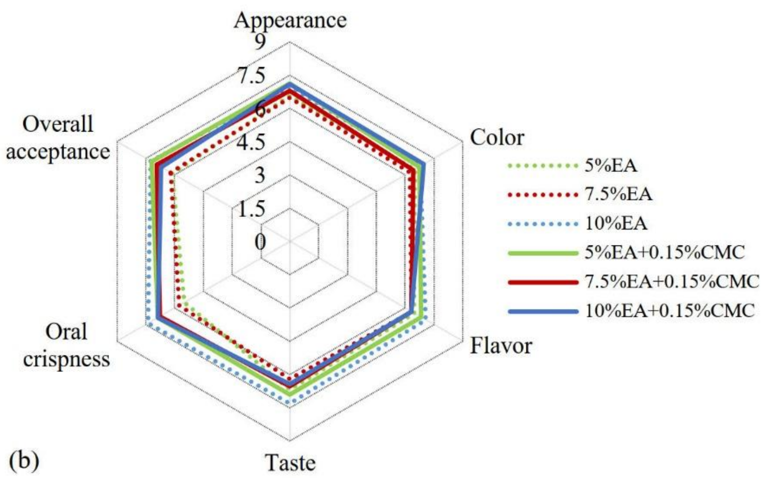

Figure 4. Visual appearance **(a)** and sensory acceptance scores **(b)** of dried banana foam snacks produced by different concentrations of egg albumin (EA), without and with carboxymethyl cellulose (CMC).

Conclusion

The present work successfully developed a dried *hom-thong* banana foam snack by incorporating egg albumin (EA) and carboxymethyl cellulose (CMC) through foam-mat drying technique, and demonstrated the influence of EA (5, 7.5, and 10%) and CMC (0 and 0.15%) concentrations on its foam properties and the characteristics of the snacks. The appropriate concentrations of EA and the addition of CMC were applied as a foaming agent and stabiliser, respectively. Formulation of the dried *hom-thong* banana foam snack was suggested at 0.15% CMC (5% EA + 0.15% CMC) compared to 10% EA. This was because the texture properties and colour parameters, as well as BI values, were lower when increasing the EA concentration in the product, which was a negative characteristic.

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