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Contributed Paper

Application of Multi-core Encapsulated *Michelia alba* D.C. Flavor Powder in Thai Steamed Dessert (*Nam Dok Mai*)

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ABSTRACT

This research aimed to investigate the suitable content of flavor encapsulated powder for controlled release and its flavor release model. The *Nam Dok Mai* (NDM) dessert was selected for this experiment due to the high moisture content and high temperature during its heating process. The controlled release of the aroma and flavor of the multi-core encapsulated *Michelia alba* D.C. (MAD) flavor powder was used in this experiment. The variations of the multi-core encapsulated MAD flavor powder (MEFP) used in this research were 0, 0.5, 1, 3, and 5% w/w. The color and texture profiles were analyzed, together with sensory evaluation. The Pandan flavor release was examined from the outer shell of the MEFP, whereas the MAD aroma release was examined from the inner core. The results revealed that the NDM dessert containing 1% w/w of the MEFP demonstrated the most preferable of the sensory preferences. The consumer acceptance of the NDM dessert with 1% w/w of the MEFP showed that the NDM dessert provided a 9-point hedonic scale sensory rating score in range of 6.0-6.3. The acceptance and purchase intention were also revealed high percentages as 98.0% and 98.3%, respectively. The controlled release model for the NDM dessert using the time-intensity method revealed the maximum intensity of the Pandan flavor and the White Champaca flavor at 48.79 and 50.80, respectively within 9thsec. This indicated that the White Champaca flavor provided higher intensity than the Pandan flavor in the NDM dessert.

Keywords: multi-core encapsulation, flavor, controlled-release, *Michelia alba* D.C., Pandan, time-intensity

1. INTRODUCTION

Food and beverages are consumed through mouth and transferred into throat before those passed through esophagus toward stomach and then adsorbed at intestines. The consumed foods through these parts of the digestive system are supposedly predigested. It is happened in oral cavity which mechanical and enzymatic degradation were taken place. The food fragments are then mixed with saliva and created consistent bolus to make it safe to swallow through digestive track. The quantity of consumed food in oral cavity each time (munching size) and other property like viscosity affected toward consumer preferences, also highly changeable among consumers. There is mandatory for breaking down a solid food in oral cavity to create smaller bite sizes than semisolid foods. The smaller bite sized is recognized to provide weaker food sensations, also lower aroma and flavor release which reduced preferable sensation toward consumers [1, 2].

The exposure aroma and flavor during consuming are affected toward consumers as following two reasons. Firstly, the perception of flavor intensity regulated adaptively from its bite size. It is suggested that the increasing of flavor intensity happens when the bite size become larger, and vice versa. Secondly, the aroma and flavor perceptions are going to be increased due to increase of fat-containing in product such as creamy or dairy product which created creaminess and thickness toward product properties [3]. The increasing of those factors lead to increasing aroma and flavor from food during consuming. The perception of aroma and flavor from food are affected from its different bite size and fat-containing property [2]. It is suggested that aroma and flavor are important parts that determined food quality and acceptability. The different content of aroma and flavor in food provided can be particularly affected toward consumers' perception and satisfaction of finished product. However, aroma and flavor are difficult to handle because of high volatility, vulnerability to oxidation and chemical reactions in applied system. Those are considerable sensitivity to expose in environment as heat, light and moisture [4].

Encapsulation techniques have been explored and applied to resolve those difficulties. The entrapments of volatile compounds are used to protect active materials from evaporation, to create resistance protective wall against undesired reactions during food processing, consuming and storage condition [4]. There are major structures of aroma and flavor encapsulation which are single core and multiple cores. The latter is the formation of different active compounds to create the property of controlled release. It mostly entraps the core materials using the complexation coacervation method. Complexation of aroma can improve food flavoring using reduction of evaporation and control of release during storage and application [5]. Microcapsules produced from coacervation are water-insoluble and heat-resistant, and possess excellent controlled release characteristics based on mechanical stress, temperature, and sustained release [6]. These have found application in many products, for instance, pharmaceutical products, beverages, bakery products, and desserts [4].

Interestingly, development of Thai desserts using such processeshas rarely ever been attempted. Most of the developed dessert premixes that are available in the market are western bakery items and desserts. There are just two developments that are involved in instant-use products and shelf-life extension of Thai desserts.

Chaysirichote. [7] carried out the study on development of instant *Khanom Tubtim*. The shelf life of *Khanom Tubtim* was extended to 3 months. Chamchan. [8] also developed instant fluffy rice flour cake (*Khanom Tauy-Fu*) for consumers who prefer convenient and easy-to-prepare Thai desserts. The result revealed that consumers accepted and preferred the instant fluffy rice flour cake product moderately. The product can be stored at temperatures ≤ 35 °C for 3 months with slight changes under an accelerated condition. Hence, Thai desserts areconsidered and developed into premixes since the ingredients of these desserts are mostly similar and the unique flavor/aroma that is dominantin them will have come from indigenous Thai herbs and flowers. Therefore, there exists the need to releaseflavor during processing, and it is from this that the flavor, preferably, slowly becomes available over an increased period of time, and not as a burst of flavor at the beginning of processing. Variations in ingredient concentrations or characteristics can modify the rheological and sensory properties of semisolid desserts, thus influencing consumer response. The effects are considerably complex. The volatile compounds engage themselves in the important role of a lypophillic in solvent, with some flavor carrier influence on the product texture [9].

The developing of the NDM dessert was carried out using data from Jueyjareon. [10], which was studied to the set specifications of the Thai steamed dessert. The study showed that the optimum formula for the NDM dessert consisted of rice flour (17.39%), sugar (26.09%), water (56.32%), and flavor (0.2%) as this formula provided the maximized preference for the product. The NDM dessert is composed of 51.07% moisture. The hardness, springiness, and gumminess of the product were 1048.27 g.Force, 5.99 mm, and 424.20 g.Force, respectively. The consumer testing of the NDM dessert revealed that the overall liking was in the category of "like moderately". The product acceptance test demonstrated that the product acceptance was 100%. Therefore, the characteristics of interest related to the particular sensory quality had to be identified and properly studied by way of a sensory analysis [10]. The time-intensity technique measures the sensory perception of a specific attribute's intensity and enables the monitoring of perceptual intensity changes during product evaluation. Recently, the time-intensity analysis has been widely used in studies to determine the behavior of food, concerned beverages, chewing gum, meat products, salad dressings, olive oil, gelatins, and dairy products [11].

The MEFP was prepared from MAD flavor powder as the inner core, whereas Pandan flavor was encapsulated in the outer shell. The Pandan flavor was released in a high-temperature and high-moisture condition while the MAD flavor was release in simulated artificial saliva fluid (SSF). In this research, the MEFP was used in the NDM dessert due to the high moisture and high temperature during heating process in order to investigate the suitable amount of MEFP in NDM dessert. The outer aroma release from the MEFP was examined during the heating process while the inner flavor was determined in SSF.

2. MATERIALS AND METHODS

2.1 The MEFP Materials and Standard Aroma References

Gelatin (Nitta Gelatin Inc., Japan) and gum arabic (Wendt-Chemie GmbH, Germany) were purchased from Union Science Co., Ltd. (Chiang Mai, Thailand). Pandan flavor (Winner Brand, Greathill, Co., Ltd., Bangkok, Thailand) was also purchased from Yok Intertrade Co., Ltd. (Chiang Mai, Thailand). All the standard chemicals (2-methyl butanoic acid, (-)-linalool, and (1s)-verbenone) were purchased from Sigma-Aldrich Co., LLC. (MO, USA).

2.2 NDM Dessert Ingredients

The NDM dessert ingredients consisted of rice flour (Hand Brand, Chiang Mai, Thailand), tapioca flour (Flying Rabbit, Bangkok, Thailand), pure refined sugar (Lin, Bangkok, Thailand), and egg yellow color (Best Odour Brand, Best Odour Co., Ltd., Bangkok, Thailand) were purchased from Yok Intertrade Co., Ltd. (Chiang Mai, Thailand).

2.3 Aroma References for Sensory Descriptive Analysis

Dried parsley, dried oregano, dried rosemary, ground cinnamon, and dried thyme (McCormick & Co., Inc, MD, USA) were purchased from Rimping Supermarket (Chiang Mai, Thailand). Fresh lemon (Sunkist, USA) was purchased from Rimping Supermarket (Chiang Mai, Thailand).

2.4 Preparation of the MEFP

The mixtures were prepared according to the method described by Alvim and Grosso [12] and Butstraen and Salaün [13] with modifications. The aqueous phase was prepared by dissolving gelatin (3% w/v) and gum arabic (3% w/v) separately in deionized water at 50 °C while stirring for 30 min until the solution dissolved into a homogenous mixture, then Pandan flavor (5% w/w of gelatin-gum arabic) was mixed together into the gelatin mixture. The MAD flavor powder was dispersed into the gelatin mixture at 2.5% w/w of gelatin-gum arabic under magnetic stirring condition (1000 rpm). The solution of gum arabic was added together to create a gelatin-gum arabic (GGA) system. The pH of GGA mixture was adjusted to 4.0±0.2 using 10% v/v acetic acid and then slowly cooled to 0 °C to create multi-core microcapsules. The mixture was stirred for another 15 min for creating the MEFP complexes extensively under magnetic stirring condition (500 rpm). The precipitated microspheres were cleansed twice by decanting with distilled water and collected by centrifugation at 5000 rpm for 5 min (Universal 320R, Hettich, Germany). The microspheres were dehydrated using a freeze dryer (Model 494830, Labconco, USA). The MEFP obtained from freeze drying were directly weighed and stored in desiccators for further analysis.

2.4 Preparation and Experiment on Formulations of NDM Dessert

The NDM dessert was modified from previously described in Jueyjareon. [10]. The modified formula of NDM dessert was consisted of rice flour (18% w/w), tapioca flour (2% w/w), sugar (23% w/w), and water (57% w/w). The production of this dessert was carried out in a steamer which was preheated to a temperature of 98±2 °C. The rice flour and the tapioca starch were mixed together separately from sugar whichwas melted in water until it was a homogeneous mass. The syrup from the sugar and water was poured into the mixture of rice flour and tapioca starch, and then kneaded until it became homogeneous. The variation of the MEFP was varied from 0.5, 1.0, 3.0, and 5% w/w with non-MEFP as a control. The mixture was poured into a preheated ceramic cup (2.5 cm. in height and 3.5 cm. in diameter) inside a steamer (98±2 °C), with each cup filled with a quantity of 12.5 g, and then the lid of the steamer was closed for 15 min. The color measurement, texture profile, flavor content, and sensory acceptance were analyzed as the following methods.

2.4.1 Color measurement

The color was analyzed using colorimeter (Colorquest XE, Hunter Lab, USA). The light source was Illuminant D65 and the Observation was 10 degrees. The color values were reported in the CIE Lab color system where L* (Lightness), a*(negative value means green and positive value means red), and b*(negative value means blue and positive value means yellow) were expressed. All the analyses of the samples were conducted in triplicate.

2.4.2 Texture profile analysis (TPA) of NDM dessert

The TPA of the NDM dessert was performed on a TA-XT plus texture analyzer (TA-XT plus, Stable Microsystems, UK) using an aluminum probe P/45C (diameter 45 mm). The TPA method was carried under the following conditions: pre-test speed, 2mm/sec; post-test speed, 1 mm/sec; rupture test distance, 1%; measurement distance, 40% deformation; force, 0.10kg; and auto trigger force, 0.020 kg. The distance from the platform was 30.0 mm, with double compression performed in intervals of 10 sec between two compressions [14]. The textural parameters calculated were hardness (g.Force), adhesiveness (g.Force), cohesiveness (dimensionless), springiness (cm), gumminess (g.Force), and chewiness (g.Force). Ten measurements were performed on each sampleto obtain the mean measurement for that sample at room temperature.

2.4.3 Quantification of Aroma of NDM Dessert using Gas Chromatograph Flame Ionization Detector (GC-FID)

2.4.3.1 Determination of pandan flavor from outer shell

The NDM dessert was analyzed for Pandan flavor release profile during the heating process. Two millimeters of the dessert slurry mixture was added into simulated heating condition in a capped 20 mL vial. A heated water bath (WB22, Memmert GmbH + Co.KG, Germany) was used as a simulated condition of the preparation of NMD with controlled temperature of 98±2 °C. The headspace vapor was sampled (5 μl) at 0, 5, 7.5, 12.5, and 15 min. The cumulative Pandan flavor content was sampled at 15 min. The considered ideal of NDM finishing time was 15 min [6].

2.4.3.2 Determination of MAD aroma from inner encapsulated powder in SSF

The MAD aroma release of finished NDM dessert from 2.4.3.1 was analyzed in SSF. The incubation was carried out in a 2 mL glass vial sealed by a screw cap covered with an aluminum foil. The 33.3 g of alpha-amylase from *Aspergillus oryzae* (EC 3.2.1.1, 30 U/mg, Sigma-Aldrich Co., LLC. MO, USA) was prepared in 10 ml carbonate buffer. The pH of SSF was adjusted to 7.2 by potassium hydroxide. The α-amylase activity used was 100 units/mL as the average activity found while chewing [5, 15]. Chopped NDM dessert (20 mg) was then incubated in 2 mL of SSF at 37±2 °C in controlled temperature water bath (WB22, Memmert GmbH + Co.KG, Germany) under continues stirring with shaker at 12 rpm (SV 1422, Memmert GmbH + Co.KG, Germany). The headspace vapor was sampled (5 μl) at 0, 1, 2, 3, 4 and 5 min. The cumulative MAD aroma content was sampled at 5 min. The considered time as ideal for maximum release in the oral cavity of the NDM dessert was 5 min. The aromas content of MAD (2-methyl butanoic acid and linalool) were analyzed followed the identification aroma from Pensuk et al. [16] investigation. In addition, verbenone was also analyzed as the other main aroma by following the identification aroma from Samakradhamrongthai et al. [17].

2.4.3.3 Gas chromatograph flame ionization detector analysis (GC-FID)

The extent of aroma released following the incubation in simulated conditions was measured by extracting aroma from the reaction medium and quantification by GC-FID. Gas chromatograph analysis was performed using gas chromatography (GC-2010, Shimadzu Corp., Japan). The column and the carrier gas (Helium) used for both the analyses were DB-1column (30 × 0.25 mm ID and 0.25 μm film thickness) (Model 122-1032, Agilent Technologies, Inc., USA) and 1.0 mL/min. The oven temperature was held at 40 °C for 3 min and increased to 250 °C at a rate of 4 °C/min and held for 5 min at 250 °C [18]. The standard calibration curves of aroma were taken into consideration in order to calculate the amount of each aroma from the NDM dessert.

2.4.4 Sensory acceptance test

All the variation formulas of the NDM dessert were presented in disposable closed-lid plastic cups coded with three-digit numbers. The tests were performed in individual air-conditioned booths (25 °C) in the Sensory Evaluation and Consumer Testing Unit (Division of Product Development Technology, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai, Thailand) and evaluated under white light, thus ensuring comfort and privacy. A complete block design was used in this experiment. The attributes of the NDM dessert were evaluated by serving the same to untrained consumers (n=50) using a 9-point hedonic scale [19] with NDM dessert attributes (appearance, color, aroma, flavor, taste, texture, and overall liking. The most preferable formulation in sensory attributes with high product acceptance was selected for further experiment.

2.5 Color Measurement, TPA, and Consumer Acceptance Test for Selected NDM Dessert

The selected NDM dessert, from section 2.4, was validated for color value, TPA, and quantification of aroma by following the method discussed in sections 2.4. The consumer test was conducted at Chiang Mai University Central Cafeteria (Chiang Mai, Thailand). The untrained consumers (n=400) were recruited from among Chiang Mai University students and officers. The selected formula of the NDM dessert was evaluated by following the Resurreccion [19] method using a 9-point hedonic scale with NDM dessert attributes (appearance, color, aroma, flavor, taste, texture, and overall liking). The preferencesas regardsthe NDM attributes were rated usinga 9-point hedonic scale. The consumeracceptance and purchasing intention were added to this evaluation, as well.

2.6 Sensory Descriptive Analysis

A sensory evaluation was conducted to evaluated flavor and time-intensity of the NMD dessert, discussed in section 2.4. The NDM dessert was used as a warm-up sample and to describe the term of aroma characteristic and the determined level of intensity of each characteristic. The prepared standard references were used for the analysis of intensity by the trained panels. The trained panels were selected by screening using a questionnaire andan odor matching test [19]. All trained panels were five males and five females from research officials and graduate students from the Division of Product Development Technology, Faculty of Agro-Industry, Chiang Mai University. The references and standards aroma for odor matching on NDM dessert were prepared using dried parsley (3.75 g), dried oregano (1.00 g), Pandan flavor (4.00 g), 2-methyl butanoic acid (0.50 g), linalool (1.50 g), dried rosemary (3.00 g), cinnamon (5.00 g), verbenone (1.00 g), dried MAD flower (10.00 g), lemon zest (7.50 g), and dried thyme (1.00 g). The training for the flavor intensity was performed by the direct approach of the individuals with the reference of the NDM dessert for each attribute (Pandan flavor, White Champaka aroma, Pandan flavor, and White Champaka flavor). The trained panels were trained in a 10 hr training session to perform the time-intensity (TI) analysis [21]. The attribute intensity level was demonstrated on a line scale (150 mm), with weak intensity at 12.5 mm and strong intensity at 137.5 mm [19]. The trained panels were trained for chewing rate at one chew per sec. The chewing rate was adjusted during the training session to be at least 29 chews within 30 sec and at the most 32 chews within 30 sec [21]. The time-intensity parameters of the attributes of interest of the NDM dessert were Pandan and White Champaka flavor, and these were analyzed as I_{max} (maximum intensity recorded by trained panels), T_{max} (time at which the maximum intensity was recorded), and Area (area of time × intensity curve; area under curve) [21]. The trained panels assessed the release flavor profile of the NDM while chewing.

2.7 Statistical Analysis

All the data was analysed and reported as mean±standard deviation of mean (SEM). Analysis of variance (ANOVA) was performed using Duncan's multiple range test (DMRT) with the significance level at 95% ($p < 0.05$). The statistical analysis was conducted using SPSS 17.0 (SPSS Inc., IBM Corp., Chicago, IL, USA) with significance level determined at 95% confidence limit ($p < 0.05$).

3. Results and Discussion

3.1 Color Values and TPA of NDM Dessert

The MEFP was made use of in the NDM dessert with its variations ranging from 0.5-5% w/w together with non-MEFP. The results showed that the color values a* and b* of the NDM dessert were significant difference as shown in Table 1. The increasing of color value a* and b* showed that MAD flavor powder inside MEFP released into dessert matrix. The redness and yellowness from MAD flavor powder distributed into the matrix to increase color value a* and b*. The increasing of MEFP also affected NDM dessert textural profile in all treatments with significant difference (Table 1). The increase in the quantity of the MEFP affected the texture of the NDM dessert significantly. The TPA results indicated that increasing the amount of the MEFP has the effect of decreasing the hardness, cohesiveness, springiness, gumminess, and chewiness. The NDM dessert that contained the MEFP was softer than the NDM dessert that contained only the dessert ingredients. This suggests that the hardness decreased because of the volume of the samples being occupied by the microcapsules consisting of gelatin and gum arabic, as reported in Meulleneti et al. [22] and Santos et al. [14]. The same results were observed for the cohesiveness, springiness, gumminess, and chewiness obtained, where the samples containing the microcapsules showed decreasing values of these parameters, as suggested in the investigations of Szczesniak. [23] and Santos et al. [14]. In contrast, the texture profile ofadhesiveness was observed to have increased when additional amounts of the MEFP were supplied, which suggests that the sample had become less adhesive and less sticky [14]. The sample with more than 3% w/v of the MEFP showed decreasing of adhesiveness, which implied that the product repossessed high adhesiveness and stickiness as suggested in the research of Santos et al. [14], both of which are unacceptable characteristics of the NDM dessert.

Table 1. Color value and textural profile analysis of NDM dessert.

Multi-core Flavor Powder (% w/w)	Color value			Hardness (g.Force)	Adhesiveness (g.Force)	Cohesiveness	Springiness (cm)	Gumminess (g.Force)	Chewiness (g.Force)
	L*ns	a*	b*						
0.0	36.54± 0.05	0.22± 0.01c	7.01± 0.03b	4426.41± 304.60a	-180.80± 29.98a	0.75± 0.03a	0.75± 0.08a	3310.81± 276.70a	2481.98± 230.60a
0.5	36.59± 0.04	0.21± 0.01c	7.01± 0.01b	4427.35± 281.91a	-181.54± 31.85c	0.75± 0.03a	0.75± 0.08a	3390.29± 336.90a	2506.59± 237.20a
1	36.60± 0.01	0.22± 0.01bc	7.01± 0.01ab	4495.82± 319.15a	-175.53± 25.91b	0.77± 0.10a	0.75± 0.12a	3482.02± 612.93a	2621.65± 636.98a
3	36.59± 0.04	0.23± 0.02ab	7.02± 0.01a	3376.55± 269.86b	-145.43± 9.38a	0.74± 0.13a	0.74± 0.12b	2514.72± 0.549.59b	1860.39± 485.56b
5	36.60± 0.03	0.24± 0.02a	7.03± 0.02a	2714.63± 261.79c	-188.10± 13.47d	0.69± 0.09b	0.61± 0.12c	1873.93± 355.63c	1119.29± 172.83c
p-value	< 0.876	< 0.001	< 0.014	< 0.001	< 0.001	0.007	< 0.001	< 0.001	< 0.001

Note: Different letters in the same column means significant difference ($p \leq 0.05$).

ns means non-significant difference ($p \leq 0.05$)

3.2 Determination of Aroma Content of NDM Dessert

The results of the analyses of all the aroma content from the NDM dessert were significant difference. The increased amount of the MEFP affected the increase in the content of the Pandan flavor and the MAD aromas as shown in Table 2. These results indicated that the content of aroma compound blended in GGA system (Pandan flavor) and dessert matrix (Pandan and MAD flavor) with increased amount of aroma as increasing of the MEFP. The higher amount of MEFP can provide higher amount of aroma. This was affected toward increasing of aroma content in NDM dessert when increasing MEFP. Seuvre et al. [24] also pointed out that those aromas are representative of the difference in polarities, volatilities, and other physicochemical properties. These characteristics changed when microcapsules were differently applied in the specific content. The phenomenon of volatile release and retention is mostly dependent on variation in its own amount. Moreover, it is extremely complex, and, therefore, there is a need to elucidate the main factors affecting these processes [23, 24].

Table 2. Aroma and flavor content of NDM dessert using gas chromatograph flame ionization detector (GC-FID) at the end of the heating (15 min).

Multi-core Flavor Powder (% w/w)	Pandan flavor (µg/mL)	Flavor Content (µg/mL)		
		2-methyl butanoic acid	Linalool	Verbenone
0.0	Not detected	Not detected	Not detected	Not detected
0.5	0.002±0.0003d	23.29±0.01d	41.25±0.69d	22.78±0.30d
1	0.034±0.0003c	62.20±0.50c	84.94±0.51c	42.16±0.22c
3	0.062±0.0002b	146.03±0.52b	247.48±0.27b	127.99±0.24b
5	0.078±0.0003a	242.24±0.33a	414.17±0.50a	251.23±0.30a
p-value	< 0.001	< 0.001	< 0.001	< 0.001

Note: Different letters in the same column means significant difference ($p \leq 0.05$).

3.3 Determination of Pandan flavor Release Profile during Heating

The Pandan flavor release profile during NDM heating showed level of aroma content related to amount of the MEFP. The NDM slurry mixture with 5%w/w the MEFP provided the highest of the Pandan flavor content (2387.59±9.58 µg/mL), followed by 3, 1, and, 0.5 % w/w, respectively (Figure 1). However, the Pandan flavor profile was not demonstrated as suggested in Dong et al. [6] study which indicated that peppermint aroma from coacervate microcapsules was increased over time-course in hot-water condition (80 °C). The cumulative releasing of peppermint from microcapsules showed 16% increasing after heating in hot water for 40 min and slightly increasing up to 20% at 60 min. The result revealed, in contrary, that the Pandan flavor was deceasing over time of heating condition (98±2°C) as shown in Figure 1. The decreased retention of Pandan flavor in the NDM dessert over time-course production occurred because of amylose-aroma and amylopectin-aroma interactions [28]. Van Ruth and King. [28] also stated that the binding of volatile compounds to starch has been categorized into two forms. It had been shown that amylose formed inclusion complexes with many volatile compounds which encapsulated in amylose helix through hydrophobic bonding. Particularly, linear molecules have been suggested to be included in the hydrophobic cavity of the amylose helix. On the other hand, volatile compounds also formed complexes with amylopectin called helical complex which bond amylopectin and volatile compounds through hydrogen bonds and also favored the hydrophobic effect [26]. The explained interactions from amylose/amylopectin and volatile compound suggested that released Pandan flavor from MEFP were able to form complexes in the NDM dessert matrix over again in dessert matrices. The retrapped Pandan flavor happened through thermal transition of the starch called gelatinization. The starch mixture of the NDM dessert changed its semi-crystalline phase to an amorphous phase with exceeded water. Sequentially, these changes facilitated starch molecular mobility in the amorphous regions and allowing the swelling of the mixture to create gel-type dessert product, resulting the retention of Pandan flavor to be deceased because of complexes recreation [26].

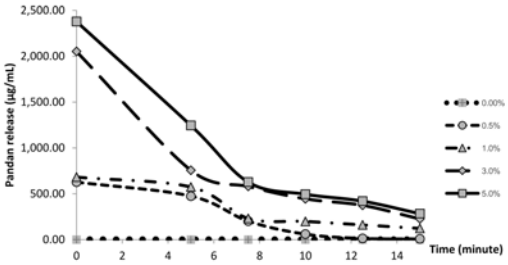


Figure 1. The Pandan flavor content releases from the NDM dessert during heating process (15 min).

3.4 Determination of MAD Flavor Powder Release Profile in SSF

The NDM dessert from 3.3 was analyzed for the MAD aroma release in SSF after the samples were analyzed for the Pandan flavor. The release of aroma of 2-methyl butanoic acid, linalool and verbenone was increased over time-course condition. The MAD main aromas content from the NDM dessert were varied. The increasing MEFP increased aroma content of the MAD main aroma through time in SSF as shown in Figure 2. The three main aromas were released through enzymatic mechanism from interaction between a-amylase and a-1,4-glycosidic bond/1, 6-glycosidic bond [5]. This showed that the MEFP was successful in retaining the aroma from the MAD extract. The hydrolysis rate found to be reduced in starch matrices, comparing to only MEFP as reported in researches from Heinemann et al. [29] and Ades et al. [5]. As for the NDM dessert release aroma, the results showed that the MAD aromas content were released at different amount. The aromas release showed that linalool provided the highest amount (41.24□0.69-414.17□0.50 mg/mL), followed by verbenone (22.79±0.30-251.23±0.30 mg/mL) and 2-methyl butanoic acid (23.29±0.00-241.24±0.33 mg/mL). According to the results, 2-mehyl butanoic acid was the fastest to release aroma from aroma-starch complex, followed by verbenone and linalool. Therefore, the result was agreed on Jouquand et al. [26] investigation that suggested volatile compounds higher molecular weight comprised lower release rate. Since, molecular weight of 2-mehyl butanoic acid, verbenone and linalool were shown as 102.13, 150.22 and 154.25, respectively. On the other hand, this result demonstrated the same direction as Naknean and Meenune. [30] review. The higher molecular weight also showed higher hydrophobicity, resulting greater retaining of aroma compound within amylose/amylopectin cavity [26]. This behavior also applied to linear carbon chain like linalool to be trapped inside starch cavity better than verbenone and 2-mehyl butanoic acid which showed that linalool and verbenone were retained longer in the encapsulated matrix than 2-mehyl butanoic acid. This suggested that the enzymatic reaction, molecular weight, complex formation, and hydrophobicity were involved in the release of MAD and it is can be applied to product that required releasing active ingredients in consumer oral cavity.

3.5 Sensory Acceptance of NDM Dessert with Variation in MEFP

The sensory acceptance score of NDM dessert five formulae showed significant difference as shown in Table 3. The appearance attribute rating was decreased when increasing the MEFP. This indicated that increasing the MEFP impacted on appearance of NDM dessert. Santos et al. [14] also stated that increasing gelatin and gum arabic which in this case a wall material of the MEFP created more adhesiveness and stickiness on the appearance of chewing gum and those were unacceptable characteristics of the product.

For other attributes, there were increasing rating score when applied the MEFP toward 1% w/w and the rating score was decreased when applied the MEFP more than 1% w/w. The NDM dessert that contained more than 3% w/w of the MEFP revealed sensory rating score lower than 6.0 with significance (p<0.05) among the NDM formulations. This suggested that increasing of the MEFP in the NDM dessert affected to decrease sensory rating score. Moreover, the product acceptance also showed that the NDM dessert with 1% w/w of the MEFP provided highest acceptance percentage (100.0%) (Table 3).

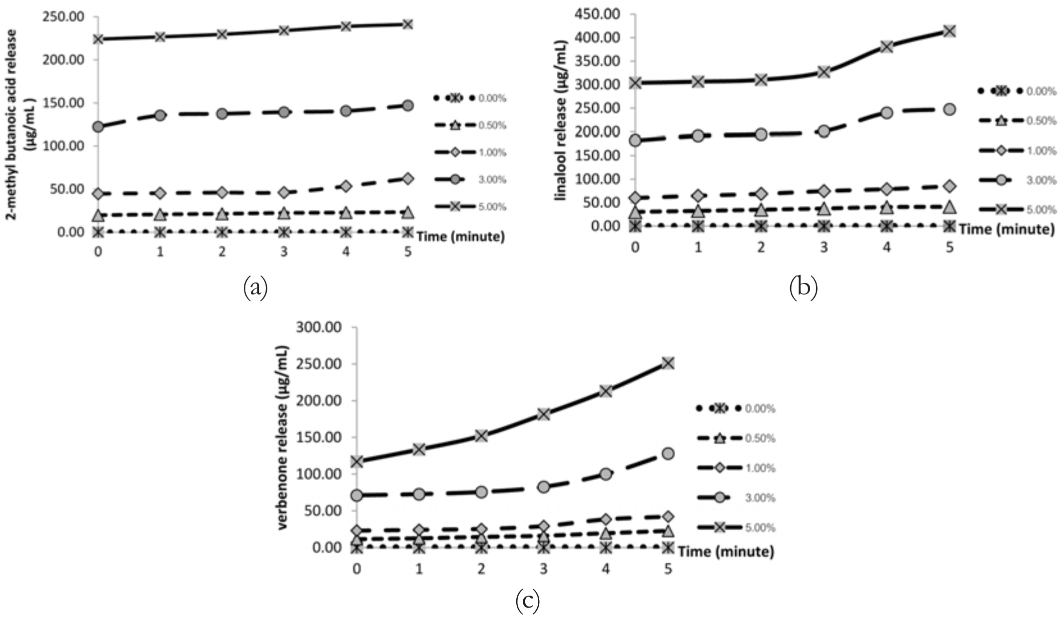


Figure 2. The release of the main aroma compounds during incubation in SSF (pH 7.0±0.2, 37°C). The aroma release was presented as the amount from the static head space; (a) 2-methyl butanoic acid, (b) linalool, and (c) verbenone.

Table 3. Sensory evaluation of NDM dessert.

Multi-core Flavor Powder (% w/w)	Appearance	Color	Aroma	Flavor	Taste	Texture	Overall Liking	Acceptance (%)
0.0	6.0±0.6a	6.1±0.5b	6.0±0.6b	6.0±0.6a	6.1±0.7b	5.9±0.7ab	6.0±0.7b	98.0
0.5	6.0±0.7a	6.3±0.5a	6.0±0.6b	6.0±0.7a	6.0±0.7b	5.9±0.7ab	6.1±0.7b	98.0
1.0	6.1±0.4a	6.2±0.5a	6.3±0.6a	6.1±0.5a	6.3±0.7a	6.0±0.6a	6.2±0.7a	100.0
3.0	5.7±0.5b	6.2±0.5ab	6.0±0.5b	6.0±0.6a	5.6±0.6c	5.8±0.6b	5.8±0.5c	90.0
5.0	5.5±0.5c	5.9±0.3c	5.7±0.5c	5.8±0.4b	5.6±0.5c	5.5±0.5c	5.6±0.5c	76.0
p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	

Note: Different letters in the same column means significant difference ($p \leq 0.05$).

3.6 Consumer Acceptance of NDM Dessert with Variation in MEFP

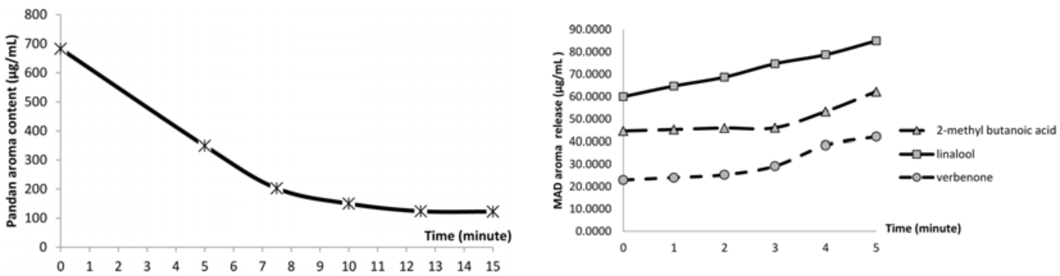
The NDM dessert with 1% w/w of the MEFP was selected from the sensory acceptance analysis as it had the highest sensory rating score and an acceptance percentage of 100%. The result from the consumer acceptance analysis showed that the NDM dessert provided a sensory rating score in the range of 6.0-6.3; the figures in parentheses denote the respective values: appearance (6.0±0.5), color (6.1±0.5), aroma (6.3±0.6), flavor (6.2±0.6), taste (6.0±0.4), texture (6.0±0.5), and overall liking (6.2±0.6). Consumer acceptance and purchase intention were also evaluated, and these showed high percentages, at 98.0% and 98.3%, respectively. As a final product, the NDMdessert with 1% w/w MEFP was analyzed for its characteristics. The NDM dessert with 1% w/w MEFP was analyzed for its characteristic as show in Table 4. The result showed that NDM dessert provided higher hardness and gumminess than the NDM from Jueyjareon. [10] research with hardness and gumminess at 1048.27 g.Force and 424.20 g.Force, respectively. This high value of hardness and gumminess were occurred because of gelatin and gum arabic from multi-core encapsulated powder which provided more gel strength toward the NDM dessert carried out from heat setting mechanism that unfolds and expanses of native starch/protein and their subsequent rearrangement into a dessert matrix. In addition, the consumer acceptance of the NDM with 1% w/w the MEFP was in the same range from Jueyjareon. [10] investigation, whereas the rating scores were slightly higher. This showed that the higher of sensory rating score can be affected from addition flavor into the NDM dessert also the product acceptance test was higher than 90% which showed that consumer accepted the NDM from this experiment as well as the NDM dessert from Jueyjareon. [10] experiment.

Table 4. The NDM dessert characteristics upon adding 1% MEFP.

Product characteristics	Analyzed value
Color value L*	44.64±0.02
Color value a*	0.71±0.01
Color value b*	9.74±0.01
Hardness (g.Force)	4522.24±344.74
Adhesiveness (g.Force)	(-177.02)±25.58
Cohesiveness	0.78±0.11
Springiness (cm)	0.74±0.12
Gumminess (g.Force)	3551.42±649.36
Chewiness (g.Force)	2639.69±654.52
Pandan flavor (μg/mL)	0.034±0.0004
2-methyl butanoic acid release (μg/mL)	61.92±0.50
linalool release (μg/mL)	84.73±0.54
verbenone release (μg/mL)	42.15±0.25

3.7 Release Content Profile of Aroma from NDM Dessert with 1% w/w MEFP

The NDM dessert with 1% w/w the MEFP was analyzed for Pandan release content during heating process and MAD aroma release content in SSF. The Pandan release content demonstrated to be decreased as expected comparing to the result from section 3.3. The amount of the Pandan was decreasing in the time-course of heating process from 682.45-122.46 μg/mL as shown in Figure 3a. This phenomenon is due to the reformation of the Pandan flavor with the starch matrix, as suggested in a review by Naknean and Meenune. [30] in which they discuss flavor carbohydrate interactions, and point out that polysaccharide solutions mostly create matrixes to entrap flavor due to their structure, particularly the amylose molecule, which normally has the ability to form V-amylose complex with the flavor molecule. The MAD aroma release content also demonstrated release profile with increasing trend, comparing to the result from section 3.4. The release profile of 2-methyl butanoic acid, linalool, and verbenone were observed and the release amount was increasing from 44.608-62.198 μg/mL, 59.959-89.943 μg/mL, and 22.945-42.160 μg/mL, respectively. The result showed success of retaining aroma from MAD extract with controlled release property through enzymatic mechanism and partially degraded from SSF as suggested in Ades et al. [5] (Figure 3b).



(a) (b)

Figure 3. The aroma release profile from the NDM dessert. (a) The Pandan flavor content release from the NDM dessert at the end of the heating (15 min). (b) The release of the main aroma compounds during incubation in SSF (pH 7.0±0.2, 37°C). The aroma release is presented as the amount from the static head space.

3.8 Evaluation and Perception of Aroma Profiling of NDM Dessert Using Descriptive Analysis Technique

The result of the matching session revealed that the trained panels matched the Pandan flavor (strong intensity), the White Champaca extract (weak intensity), and the dried White Champaca petal (weak intensity) for the NDM dessert aroma. In addition, the Pandan flavor (medium intensity) and the dried White Champaca petal (strong intensity) were matched for the NDM dessert flavor. Pandan and White Champaca were agreed upon as references for aroma and flavor. The order of the aromas was perceived to be in the order of the Pandan flavor and the White Champaca aroma, respectively. The similar aromas were perceived with variation of intensity, which occurred from the differences in the perception of aroma by the trained panels. The conclusion of terms and definitions from the NDM dessert were described using the Pandan flavor and the dried White Champaca. The intensity of the Pandan was designated for the threshold of aroma as low, medium, and high at 20.00 mm, 60.00 mm, and 80.00 mm, respectively. The intensity of the White Champaca was designated for the threshold of aroma as low, medium, and high at 10.00 mm, 30.00 mm, and 60.00 mm, respectively.

The descriptive analysis of NDM dessert revealed that the average rate of chewing was 30 chews per 30 sec (30±0.6). The Pandan aroma and flavor had higher intensity than the White Champaca in the NDM dessert. The intensity of the aromas from the NDM dessert were dictated by the trained panels as Pandan aroma (13.80±0.92), White Champaca aroma (9.24±0.22), Pandan flavor (40.03±1.06), White Champaca flavor (30.43±1.14), Panda aftertaste (11.5±0.25), and White Champaca aftertaste (36.1±0.83).

The controlled release of flavor was investigated using the time-intensity method. The trained panels were requested to consume the NDM dessert and rate the flavor intensity of the Pandan flavor and the White Champakc flavor within 20 sec of Time initiate (T_i) at 0 sec and Time end (T_e) times at 20 sec. The flavor intensity of the Pandan and the White Champaca were plotted to create the trend of the flavor release in the oral cavity. The result showed that the intensity of the Pandan flavor and the White Champaca flavor were initiated at 35.83 and 30.96. This is because the Pandan flavor was released prior to the heating process of the NDM dessert and the White Champaca flavor from the MAD flavor powder was still contained within the NDM dessert matrix. The maximum intensity and the maximum time (I_{max} and T_{max}) of the Pandan flavor and the White Champaca flavor were 48.79 and 50.80, respectively, at the 9th sec. The area under the curves showed that White Champaca exhibited higher intensity than Pandan at 822.98 and 763.03, respectively (Figure 4). This suggests that the differencein theI_{max} and the T_{max} were because of the enzymatic reaction of α-amylase while chewing. The flavors were released through the enzymatic reaction in the saliva that breaks the 1,4 and 1,6 linkages in the OSA starch [5]. Moreover, the mechanic shear force from chewing is another factor that assists the release of flavor in the oral cavity. This suggests that the overall flavor from the NDM dessert showed higher intensity of the White Champaca flavor than the Pandan flavor, as suggested in Cadena et al.[11], in which it is mentioned that the parameter area under the curve showsthe absolute value of the attribute intensity. The higher area value provides more intense and more persistent results than others. These results revealed that the MEFP that was made use of in the NDM dessert was successful in the controlled release of the Pandan flavor and the White Champaca flavor, and that the release can be delayed in the oral cavity of consumers.

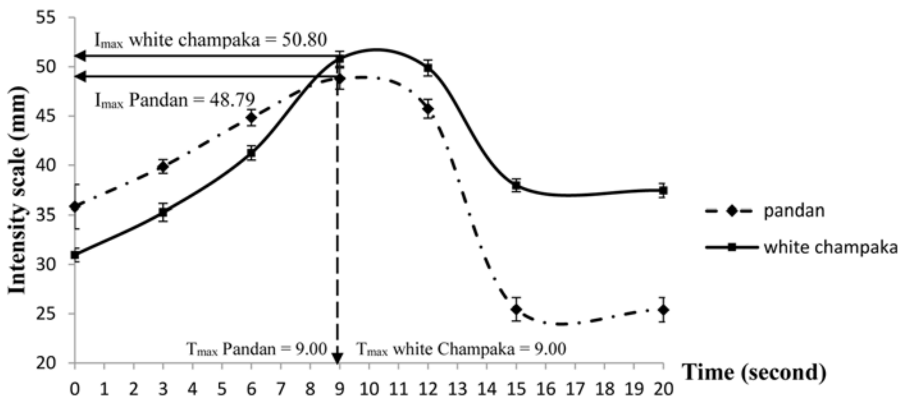


Figure 4. The time-intensity of the Pandan flavor and the White Champaca flavor in the NDM dessert.

4. Conclusions

The NDM dessert containing 1% w/w of the MEFP proved to be the most preferable as regardssensory preference. The consumer acceptance analysis results of the NDM dessert with 1% w/w of the MEFP revealed that the NDM dessert provided sensory rating scores in the range of 6.0-6.3. Thus, the MEFP at 1% w/w was the most suitable for this formula of the NDM dessert. In addition, Product acceptance and purchased intention of the NDM dessert with 1% w/w MEFP were also showed high percentages at 98.0% and 98.3%, respectively. The controlled release model ofthe NDM dessert from the time-intensity method revealed that the maximum intensity of the Pandan flavor and the White Champaca flavor were 48.79 and 50.80, respectively, at the 9thsec.It was indicated that the White Champaca showed higher intensity than the Pandan because of the Pandan flavor was released prior through the heating of the NDM dessert while the White Champaca flavor from the MAD flavor powder was contained within the NDM dessert matrix. Additionally, the mechanical shear force from chewing was another factor that assisted the flavor release in the oral cavity. This demonstrates that making use of MEFP in the NDM dessert for the controlled release of the flavors of the Pandan and the White Champaca is a success and that the release can be delayed in the oral cavity of consumers.

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