CLSU International Journal of Science and Technology
www.clsu-ijst.org
ISSN 2507 -9638 (online)
The CLSU International Journal of Science and Technology was previously published as CLSU Scientific Journal since 1965.

The Potential of Microalgal Powder in the Enhancement of Pysicochemical and Sensory Properties of Cakes

Peng Soo Yee[1] and Hazel Monica Matias-Peralta[2]

[1]Department of Technology and Natural Resources, Faculty of Applied Sciences and Technology, University Tun Hussein Onn, Malaysia
[2]College of Fisheries – Fresh Aquaculture Center, Central Luzon State University, Philippines

Email for correspondence: hazelperalta@clsu.edu.ph

Submitted: June 1, 2023. Accepted: June 15, 2023. Published Online: August 31, 2023.

Abstract

Cake is very popular bakery product, generally high calories due to high fat content. The objective of this study was to evaluate the physicochemical properties, and consumer acceptance of butter cakes supplemented with two different concentrations of microalgae *Scenedesmus* powder (5% and 10%) as partial replacement for fat content used in cakes. Microalgae are a rich source of proteins, vitamins, minerals, antioxidants, essential amino acids and fatty acids. The mean water activity of the control butter cake prepared with 100% butter with a value of 0.94 was higher ($p<0.05$) than the butter cake containing microalgae powder. Addition of *Scenedesmus* powder imparts a green colour to the product. For the butter cakes with increased amount of microalgae powder, the *L**- ,*a**- and b*- value decreased significantly ($P<0.05$). The lowest ($P<0.05$) firmness were observed for the butter cake containing the highest concentration (10%) of *Scendesmus*. Consumer acceptance evaluated using a structured nine points hedonic scale found that 5% replacement of microalgae powder had the higher overall acceptability compare with 10%. Overall, *Scenedesmus* butter cake could be developed with comparable physicochemical qualities without sacrificing consumer acceptability.

Keywords: Microalgae, Scenedemus, cakes, physicochemical properties, consumer acceptance

Introduction

Cakes are the most popular among bakery products. Cake is made with mixture of flour, sugar, eggs, oil or fat, liquid, and leavening agents. Cakes are known to be high in calories due to high fat and sugar content. Fats play an important role which carry the flavour of the final products and provide good rich taste of a cake. Fats contribute tenderness, moistness, and a smooth mouthfeel to baked products. The normal types of fat used in baking are shortening, butter, margarine and oil. Various efforts have made to reduce the fat and calorie contents in cakes by replacing shortening. High fat diet may lead to several health problems such as obesity and cardiovascular disease. Consumers are demanding high number of low-calorie products as they strive to make healthier food choices.

In lieu of this demand, microalgae has been suggested as having the best potential as healthier alternative in food products application. Microalgae are photosynthetic prokaryotic or eukaryotic microorganisms which produce carbohydrates, proteins, and lipids through the process of photosynthesis. According to Kumar et al. (2015) Scenedesmus sp. is a potential food additive due to their high nutritional value. In fact, Cofrades and Serdaruglo (2013) reported the use of microalgae as food ingredients, sources of bioactive substances and high value chemicals and pharmaceuticals. They noted that microalgae biomass consists of a variety of chemical compositions which can used to enhance the nutritional content of food products.

In order to reduce the incidence of food related diseases and to improve the health status, development of foods rich in nutrient with low calorie may play a major role in securing the health of consumers. Methods of formulating cakes with microalgae powder can help develop cakes containing healthy fats (particularly the unsaturated and polyunsaturated fats) and reduced cholesterol content. The incorporation of microalgae powder can improve the nutritional value of cakes. With the use of microalgae powder as fat replacer in baking, consumers can benefit with health-enhancing effects and enjoy cake products without the guilt (Lim et al., 2010). Therefore, this study aimed to evaluate the physicochemical properties, and consumer acceptance of butter cakes supplemented with microalgae, Scenedesmus powder as partial replacement for fat in butter cake.

Materials and Methods

Microalgae Powder Preparation

The freshwater microalgae, Scenedesmus sp. isolate was cultured in Bolds Basal Media (BBM) for a period of 3-4 weeks until the microalgae reached its full growth capacity (with cell density of 10^9 cells per ml). Microalgal cells were harvested by centrifugation at 4000 rpm for 10 minutes and washed with sterile pure water for three times upon which the pellets collected were freeze dried to obtain the powder.

Butter Cake Preparation

Creaming method was used to bake the butter cakes with some modification adapted from Marina et al. (2016). The ingredients required are all purpose flour (110g), self-rising flour (110g), baking powder (3g), butter (150g), whole eggs (150g), sugar (100g), and milk (125mL). All the ingredients were weighed using electronic balance. The mixture were prepared by creaming butter with sugar with an electric mixer for 8 minutes. Then, the rest of the ingredients were slowly added under constant mixing. The other dry ingredients were also added while creaming on medium. The batter were poured into cake pans and baked in the preheated (175°C) oven for approximately 45 minutes at 180°C. Butter cake was formulated with 5% and 10% by weight replacement of butter with microalgae powder (Table 1). The cake were cooled down at room temperature before quality determination.

Table 1. Formulations of butter cake with microalgae powder

Types of butter cakes	Weight of butter used	Weight of microalgae powder
Control butter cake	150g	0g
5% replacement butter cake	142.5g	7.5 g
10% replacement butter cake	135g	15.0 g

Physical Analysis

Water Activity

Water activity was determined following the method described by Nielsen (2014) using a water activity meter (AL1823, AquaLab, USA). The water activity meter was

calibrated prior to the testing. The test sample temperature were kept less than the chamber's temperature. The grinded and homogenised samples were spread evenly to ensure the bottom of the sample cup is completely covered. The sample cup was filled to half full. Then, the sample cup was transferred into the water activity meter chamber and secured. The measurements were carried out in triplicate for each power-time combination to the butter cakes sample.

Texture

The cakes firmness and springiness were determined by using the Texture Analyzer (TA-XT plus, Stable Micro System, UK). After the butter cake cools for 1 hour at room temperature, each inner part of cake slices 25×25×25 mm cubes were prepared. The force was measured at which the height of the cakes was compressed by penetrating to 50% of the cake slices depth at a speed of 2mm/s. The maximum peak force value in the graph was recorded for each cake formula and the average was calculated in force unit (g) (Hafez, 2012).

Colour

Colour spectrophotometer (4500L, HunterLab, US) was used to determine the colour profile of the cakes. Standardization and calibration was done using black and white glass. The sample was transferred into petri dish and scanned with the colour spectrophotometer. L*, a*, b* value can be obtained from the screen. L*indicates the brightness while L= 0 to blackness (total colour absorption). a* represents the greenness and redness where a^+ refer to redness and a^- refer to greenness. Yellowness and blueness will be represented by b* as b^+ indicates yellowness while b^- indicates blueness [7]. Each cake sample from each variable and trial was taken from the center area of the cakes to avoid crust areas that could vary in darkness. A petri dish was filled with the cake sample and readings were taken.

.

Sensory Evaluation

Affective test (Singh et al., 2016) was conducted by 100 untrained panellists consisted mainly of students and staff of the Universiti Tun Hussein Onn Malaysia to evaluate three butter cake formulations. The first sample was the normal butter cake while the other two are butter cakes formulated with different concentration of microalgae powder. The samples were labelled with three-digit code before presenting to the panellists. Affective test was carried out using hedonic scale. The scale of values ranged from dislike extremely (score 1) to like extremely (score 9). Hedonic scale from 1 - 9 was used to evaluate the overall acceptability, flavour, aroma, aftertaste, mouthfeel and colour of the cakes. Ten minutes prior to the evaluation, the panellists were briefed as to the aim of the test. The sensory test was conducted in the sensory evaluation laboratory, a laboratory specially designed to prevent odour and sound interference. The data collected from the evaluation were analysed for each of the attribute by calculating the mean point from the results. Quantitative descriptive analysis (Spider web analysis) was done on each of the formulation

Results and Discussion

Water Activity

The highest mean water activity was observed in pure butter cake samples compared to those butter cake with microalgae powder (Table 2). The results perhaps indicated that partial replacement of butter with microalgae powder was able to reduce water activity of the butter cake. A significant reduction in water activity by partially replacing the butter with microalgal powder will enhance the shelf life of the butter cakes. This is because lower water activity means lower microbial growth which translate to a better quality and safety of the product (Barbosa-Cánovas et al., 2020). Furthermore, according to Batista (2017), microalgae have high antioxidant activities which will also help in controlling microbial growth in the cakes. In particular, high water activity in baked products allows and supports growth of moulds in cakes. Hence the lower the water activity the better the product.

Table 2. Water activity of control and enhanced butter cakes.

Formulation of cakes	Water activity (a_w)
Control butter cake	*0.94±0.006[a]*
5% microalgae butter cake	*0.88±0.003[b]*
10% microalgae butter cake	*0.87±0.004[b]*

Texture

The texture profile analysis showed butter cakes without partial replacement of microalga powder achieved the highest (P<0.05) firmness. However, when it comes to springiness, butter cakes with partial replacement (5% and 10%) of microalgae yielded the highest (P<0.05) value of springiness. The values of firmness of control sample were higher than both of the microalgae formulation butter cakes whereas springiness value was the lowest. Springiness shows how well the cake springs back after it has been deformed during the first compression. The highest springiness was found in the butter cake which supplemented with 10% microalgae powder. There was significant difference (p<0.05) in tenderness scores for all formulations indicated that microalgae Scenedesmus powder did affect the texture of butter cakes.

The lowest hardness was found for the treatment containing the highest amount of microalgae (10%). A lower firmness value indicates a softer texture of cakes. According to the results of TPA, increased level of Scenedesmus microalgae powder in the formulation of butter cake reduced hardness. Both butter cakes supplemented with microalgae Scenedesmus powder showed better textural parameters (low hardness, high springiness values) compared to the control butter cake. It is evident that from previous study by Golmakani et al. (2015) that the lowest hardness, chewiness, and gumminess were found in the cupcake containing the highest amount of microalgae Spirulina powder.

Table 3. Texture of different formulation of butter cakes

Types of Formulation	Firmness (g)	Springiness (%)
Butter cake	587.74±2.18a	35.76±1.33b
5% microalgae cake	436.16±5.10b	42.51±0.75a
10% microalgae cake	374.67±19.94c	45.86±1.37a

Table 4. The average and standard deviation of colour measurement for butter cakes

Sample	Colour		
	*L	*a	*b
Formulation 1 (0%)	67.72±0.40	9.08±0. 20	36.12±0.92
Formulation 2 (5%)	37.67±0.76	-4.86±0.06	27.97±0.33
Formulation 3 (10%)	32.63±.0.99	-3.83±0.18	22.32±0.65

The highest of L* values was found in cake prepared from 100% of butter or 0% of microalgae powder and L* gradually decreased in cake substituted butter with microalgae powder from 5% (7.5g) to 10% (15g). For the butter cakes with more amount

of microalgae powder, the *L**- ,*a**- and b*-value decreased significantly (*P*<0.05). The colour of samples was affected by the replacement of cake flour with microalgae *Scenedesmus* powder. Addition of *Scenedesmus* powder imparts a green colour similar to pandan (*Pandanus amaryllifolius*) flavoured cakes. In addition, decreased lightness is generally observed in *Scenedesmus* fortified cakes because the deep green coloured microalgal biomass makes the products darker. Microalgae are recognized as an excellent source of pigments such as chlorophylls, carotenoids and phycobiliproteins (Nacim et. Al., 2011).

The main factor causing the colour change of the cake is due to the pigment of *Scenedesmus* powder, as the level of substitution increased lightness of the cakes decreased and greenness increased. As the level of microalgae powder increased, the L, a and b values decreased, indicating that a darker, less redder, and less yellow crumb was obtained as a result of microalgae powder substitution. As the amount of microalgae powder was increased, the cake crumb became darker (lower *L* values), more yellow (higher b values), and less green (lower negative a values) when compared with the control. Similar conclusion was reported by Figueira *et al.* (2011) and Huch (2014) that a reduction of the brightness of the crumbs in cupcakes was also achieved with an increase in the concentration of added *Spirulina*.

Table 5. The average score and standard deviation of sensory evaluation for 3 different butter cakes formulations which are randomly coded with 328, 508 and 786.

Attributes	Control	5% Microalgal Powder	10% Microalgal Powder
Colour	7.53±1.17	6.57±1.42	5.79±1.60
Aroma	7.25±1.31	6.24±1.69	5.79±1.89
Taste	6.59±1.43	6.67±1.31	5.84±1.80
Texture	6.61±1.59	6.48±1.39	5.97±1.93
Overall acceptability	7.14±1.23	6.61±1.26	5.83±1.72

Overall the control butter cake ranked as the best in terms of all the sensory parameters except the taste. The mean scores for colour ranged from 5.79 to 7.53 with the control product (0% microalgae) significantly recording a higher appeal. The highest mean score for taste is the 5% microalgal powder with score of 6.67. The presence of microalgae powder in the formulations significantly influenced the taste of the cake products. Butter cakes with 5% microalgae rated better in taste than cake products with 10% microalgae. Among the three different types of the butter cakes, the formulation with total butter cake had a higher sensory texture score than the formulation with microalgae powder. The butter cakes containing 10% microalgae powder received low scores for all the attributes. The overall acceptability decrease may be related to the aroma, taste and darkness of the colour. The aroma and taste of the cakes with 10% *Scenedesmus* powder was more strongly expressed in terms of odour which was less accepted by the consumer. In the other words, the more *Scenedesmus* powder added, the less preferred the butter cakes will be. There was significant difference in all cakes formulation in terms of the overall acceptability with a range of 5.83-7.14 on a 9-point hedonic scale. From the results, we can indicate that all the cake samples were accepted by the panelists. Accordingly, is it possible to conclude that consumers would be willing to forsake certain attributes in order to gain a potential health benefit from consuming this product (Table 5). It could be a new option of healthy food which reduces the fat content used in bakery products instead of taking microalgae supplement if this product were commercial in food industry. The result suggested that microalgae powder could economically be substituted instead of butter in cake production to improve the

nutrient content without reducing the sensory quality.

Conclusion

In conclusion, *Scenedesmus* microalgae powder butter cake could be developed with comparable physicochemical qualities without sacrificing consumer acceptability. It may be concluded from the present study that microalgae powder can be incorporated into the butter cake up to 5% to yield cakes of enhanced nutritional quality with acceptable sensory attributes. Addition, of microalgae powder greatly influenced both sensory and instrumental texture characteristics of the butter cake. Likewise, *Scenedesmus* powder imparts a green colour to the butter cake, lower the water activity and reduces hardness which gives the butter cake a soft texture. The overall acceptability of the products was good proving that cakes were accepted by the panellists. Since other attributes in particular the color, gained lesser acceptability score, more studies should be conducted to investigate this further. This was the first time the microalgal fortified butter cake was introduced to the panellist, so there is high probability that exposing them more with this kind of preparation will lead to acceptance. In addition, potential of using as microalgae *Scenedesmus* powder as ingredient on other food products in order to increase the application of such value added food ingredient is great.

.

Acknowledgements

The authors are grateful for the support for any parties that are involved in this project, especially University Tun Hussein Onn Malaysia for providing the research facilities to carry out this project.

References

AOAC (2000). *Official Methods of Analysis of the Association of Official Analytical Chemists.* Washington: DC.

Barbosa-Cánovas, G.V., Fontana Jr., A.J., Schmidt, S.J., and Labuza, T.P. (2020). Water Activity in Foods: Fundamentals and Applications, 2nd edition, John Wiley & Sons, Inc.

Batista, A.P., Niccolai, A., Fradinho, P., Fragoso, S., Bursic, I., Rodolfi, L., & Raymundo, A. (2017). Microalgae biomass as an alternative ingredient in cookies: Sensory, physical and chemical properties, antioxidant activity and in vitro digestibility. Algal Research 26:161–171

Cofrades, M. and Serdaroglu, S. (2013). *Design of Healthier Foods and Beverages Containing Whole Algae.* USA: Woodhead Publishing.

Golmakani, M., Moayyedi, M., Raissjalali, A., Pesaran, Y., & Aghajani, A.R. (2015). Investigation of Physicochemical, Nutritional, Textural, and Sensory Properties of Iranian Yazdi Cupcake Enriched with Spirulina (*Arthrospira platensis*).

Hafez, A.A. (2012). Physico-Chemical and Sensory Properties of Cakes Supplemented with Different Concentration of Marjoram. *Aust. J. Basic Appl. Sci.*, 6 (13):463–470.

Huch, A. (2014). Technological quality of bread from rice flour with Spirulina. 21(4):1523–1528.

Kumar, S. A., Magnusson, M. Ward, L. C. Paul, N. A. and Brown, L. (2015). A Green Algae Mixture of *Scenedesmus* and *Schroederiella* Attenuates Obesity-

linked Metabolic Syndrome in Rats. *Nutrients*, vol. 7, no. 4, pp. 2771–2787.

Lim, L. Inglett J. B. and Suyong G. E. (2010). Response to Consumer Demand for Reduced-Fat Foods; Multi-Functional Fat Replacers. *Japan J. food Eng.*, vol. 11, no. 4, pp. 1–6.

Marina A.M., Nurhanan A.R., Wan Rosli W.I., & Nurul Ain O. (2016) Physical properties and microstructure of butter cake added with Persea americana puree. Sains Malaysiana, 45(7):1105-1111. ISSN 0126-6039

Nacim, Z., Mouna, A., Nahed, F., Ayadi, M.A., Zourgi, L., & Hamadi, A. (2011). Blue-green algae (*Arthrospira platensis*) as an ingredient in pasta : Free radical scavenging activity, sensory and cooking characteristics Evaluation. *International Journal of Food Sciences and Nutrition.* 62(8): 811–813.

Nielsen S. (2014). *Food Analysis*, 4th ed. USA.

Singh, J. P., Kaur, A., & Singh, N. (2016). Development of eggless gluten-free rice muffins utilizing black carrot dietary fibre concentrate and xanthan gum," *J. Food Sci. Technol.*, 53: 1269–1278.