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Development of a healthier durian cookie enhanced with inulin

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Abstract Cookies are characterized by their high sugar and fat contents. To enhance their nutritional profile, the incorporation of functional ingredients such as inulin has been proposed. The results indicated that the substitution of durian powder led to a reduction in moisture content, lightness (L*), yellowness (b*), and caloric value, while hardness and redness (a*) increased. The cookies with 20% w/w durian powder exhibited the highest overall acceptability ($\rho \leq 0.05$). Thus, this formulation was selected for further investigation, where sugar was partially replaced with inulin at concentrations of 0%, 20%, 40%, and 60%w/w, respectively. The results demonstrated that the substitution of inulin tended to decrease lightness (L*) and yellowness (b*), while moisture content, hardness, calories, and redness (a*) increased. In sensory evaluation, cookies with 20% w/w inulin supplementation received significantly ($\rho \leq 0.05$) higher scores for taste, texture, and overall liking. Interestingly, the caloric content of the developed durian cookies was significantly lower ($\rho \leq 0.05$) than that of the control cookies. Scanning electron microscope analysis revealed the presence of an inulin gel network within the cookies. In conclusion, this study offers important insights into the development of healthier cookies utilizing low-grade durian, presenting a significant opportunity for food manufacturers to address the current market demand for healthier dietary options.

Keywords: Durian, Cookie, Prebiotic, Inulin

Introduction

At the present time, the rising prevalence of fast-food consumption, coupled with a decline in the intake of dietary fiber, has contributed to an elevated risk of obesity and cardiovascular diseases (Dharma and Insani, 2020). Hence, there has been a growing consumer demand for foods that offer additional health benefits and fulfil nutritional needs, particularly in the context of preventing non-communicable diseases (Abed *et al.*, 2016). The intake of prebiotics aimed at improving human gastrointestinal health is on the rise, as they promote the proliferation of probiotics within the intestinal tract (Thammarutwasik *et al.*, 2009). Inulin, a notable prebiotic classified as polyfructans, is extensively used

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in many different areas, including as a prebiotic agent, sugar substitute, fat replacer, and for texture enhancement. Its diverse functional and nutritional attributes render it a crucial ingredient in the food industry. Moreover, its characteristics can enhance the mouthfeel, as they are directly associated with the properties of other sugars (Abed *et al*., 2016). Furthermore, inulin promotes the proliferation of native *Lactobacillus* sp. and *Bifidobacterium* sp. by enhancing the colonic production of short-chain fatty acids. These compounds are linked to a decrease in mucosal permeability, which supports the preservation of microbial communities and improves the efficacy of epithelial barriers that is crucial for providing optimal protection against pathogen invasion, translocation, and the prevention of gastrointestinal diseases (Kolida *et al*., 2002; Akram *et al*., 2019).

Durian (*Durio zibethinus* Murr.) is a fruit indigenous to Southeast Asian countries including Malaysia, Indonesia, and Thailand (Aziz and Jalil, 2019. This fruit is renowned for its distinctive and exotic flavor profile, characterized by its unique taste and aroma. When fully ripened, the fruit exhibits a soft and creamy yellow texture (Charat *et al.,* 2022). Recent reviews have shown that durian is rich in macronutrients, including fats and proteins), as well as a variety of minerals, flavonoids (such as flavonols and anthocyanin), and essential vitamins, including vitamin C, B complex vitamins, and carotenoids (Aziz and Jalil, 2019). In addition, durian exhibits a low glycemic index (GI = 49) in comparison to other tropical fruits such as papaya, pineapple, and watermelon (Robert *et al.*, 2008). Furthermore, the pulp of its fruit has been recognized as a valuable source of nutrients, containing protein (1.47%), fat (5.33%), fiber (3.1%), and carbohydrates (27%) (Devalaraja *et al*., 2011). Indeed, durian is regarded as exceptional and palatable for those who appreciated its distinctive aroma and taste (Tan *et al.,* 2023).

Nonetheless, the price of durian can occasionally pose a significant challenge, particularly when there is an oversupply during the harvest season or when the fruit does not meet quality standards. Consequently, numerous initiatives have been undertaken to enhance the value of durian crops (Pertiwi *et al*., 2018; Dharma and Insani, 2020; Mahyiddin *et al*., 2022). One viable solution to address these issues is the production of durian-based cookies.

Cookies are widely regarded as a favoured snack across various age groups with the community. These baked goods are primarily composed of flour, sugar, and fat, resulting in a small delectable product. The main ingredients of cookies include butter, flour, and sugar often supplemented with additional ingredients to enhance their flavor and aroma (Duncan *et al*., 2011). Consequently, these treats typically possess a significant concentration of fat and sugar (Dharma and Insani, 2020). From a nutritional perspective, the incorporation of durian and the enhanced nutritional profile of cookies has led to numerous studies aimed at creating cookies enriched with bioactive ingredients, thereby converting them into functional foods. Pertiwi *et al.* (2018) examined the moisture, ash, protein, fat, and carbohydrate levels in cookies produced from durian seed flour. The results indicate that the intake of durian seeds should be limited to no more than 10% of an individual's overall dietary consumption. Charoenphun and Kwanhian (2019) conducted a study aimed at optimizing a recipe for gluten-free cookies that incorporated dietary fiber derived from durian rind. The findings indicated that cookies produced from a blend of flours represented the most effective alternative to traditional wheat flour. Additionally, the cookies containing green tea powder and coffee powder received a higher average score for flavor and taste compared to other formulations. In the same year, Suppramaniam *et al*. (2019) investigated the effects of cookies made with durian and β-glucan on glycemic index, acceptability, palatability, and perceived satiety. It was found that cookies made with durian and β-glucan are considered acceptable and could potentially reduce the GI when compared to the control group. Moreover, Dharma and Insani (2020) explored the use of durian seed flour in the production of a nutritious cookie product, examining how varying formulations of durian seed flour (0%, 25%, 50%) influenced the organoleptic properties of the cookies. Their findings indicated that cookies incorporating durian seed flour exhibited overall organoleptic attributes, particulary in terms of texture. Additionally, Mahyiddin *et al*. (2020) investigated the addition of nutmeg (*Myristica fragrans*) essential oil to enhance the aroma, serving as a substitute for rum in cookies made from flour derived from durian (*Durio zibethinus*) seed waste. Their findings indicated a positive consumer acceptance of this innovative product.

Despite the interesting properties of durian outlined previously, there exists a lack of research focused on the creation of a healthier durian cookie incorporating inulin. Therefore, the development of durian cookies that utilized inulin as a substitute is assessed to enhance their nutritional profile. Subsequently, various physicochemical and sensory characteristics were evaluated.

Materials and methods

Materials

The formulation of the cookies involved several key ingredients, including durian powder (Queen Bakery 99 Limited, Thailand), wheat flour (UFM Food Center Limited, Thailand), butter (KIG Corporation Limited), sugar (Mitr Phon Limited, Thailand), eggs (Food Charoenpokapon, Thailand), vanilla extract

(Great Hil Limited), salt (Salt Industry Limited), milk powder (JP Golden Celt Limited), and baking powder (Best Order Limited). All ingredients were sourced from a local market located in Chanthaburi, Thailand. Following this, the samples were conveyed to the laboratory and maintained at room temperature before the preparation of the durian cookies. Additionally, inulin powder was acquired from Herb Paina House Limited, also a Thai product.

Development of durian cookies

The experiment was conducted using a completely randomized design (CRD) with four treatments, each replicated three times. Initially, four different concentrations of durian powder (0%, 10%, 20%, and 30%w/ w) were incorporated into wheat flour in the formulation. Consequently, four variations of durian cookies were produced (Table 1). The control sample consisted of a cookie made solely with wheat flour, excluding any durian powder.

Table 1. Four essential ingredients for the preparation of durian cookies

Ingredients (g)	**Durian powder concentration (%w/w)**			
	0(Control)	**10**	**20**	**30**
Wheat flour	300	270	240	210
Durian powder	0	30	60	90
Baking powder	2.6	2.6	2.6	2.6
Milk powder	7.5	7.5	7.5	7.5
Butter	225	225	225	225
Salt	0.9	0.9	0.9	0.9
Sugar	125	125	125	125
Vanilla extract	3	3	3	3
Egg	50	50	50	50

In the production of durian cookies, the initial step involved thoroughly combining butter, eggs, and vanilla extract with an electric hand mixer (model: Electrolux EHM 3407, Thailand). Then, wheat flour, baking powder, durian powder, and milk powder were added and blended until homogenous. The resulting mixture, was then transferred into a piping bag. The durian cookie dough was piped onto a tray lined with the baking paper. The cookies were baked in an oven (model: Sharp, EO-42K, Malaysia) at 180°C for a duration of 15 minutes (Charoenphun, 2018). Following the baking process, the cookies were allowed to cool before undergoing analysis for their physicochemical properties and sensory evaluation.

The determination of physical characteristics involved the evaluation of durian cookies that were formulated with varying concentrations of durian powder, focusing on colour parameters and texture. Colour determination was conducted using a colour meter (model: CR-400 by Konica Minota, Japan), which was calibrated with a standard reference plate. The colour measurements were expressed in terms of L*, which denotes lightness on a scale from 0 (black) to 100 (white); a* values (+, -) indicate the degree of redness or greenness; b* values (+, -) indicate the degree of yellowness and blueness. Texture analysis was performed using a texture analyzer (model: LLOYD Instruments, TA plus, UK).

The moisture content was analyzed using a moisture meter (model: Sartorius, MA150, Germany) for the chemical characteristics, while the caloric determination was determined through a bomb calorimeter (model: Parr, 610 calorimeters, USA).

The sensory characteristics of four different formulations of durian cookies were evaluated involving a sensory evaluation conducted with 30 untrained panelists comprising staff and students from the Department of Food Innovation and Business at Rajamangala University of Technology Tawan-ok, located in Chanthaburi Campus. The panelists utilized a nine-point hedonic scale, where 1 represented "extremely dislike" and 9 indicated "extremely like" (Watts *et al*., 1989). Each panellist evaluated the samples based on criteria including colour, aroma, taste, texture, and overall acceptability.

Development of durian cookies with added inulin

The best formulation for the development of durian cookies was selected for investigation in this study. The experiment was conducted using a Completely Randomized Design (CRD) with four treatments, each replicated three times. The formulations for the durian cookies were created by partially substituting sugar with inulin at levels 0%, 20%, 40%, and 60% w/w. The production of durian cookies followed the previously outlined procedure. Subsequently, various physicochemical and sensory characteristics were analyzed as previously described. Finally, the microstructure of the baked durian cookies was examined using scanning electron microscopy (SEM; model JEOL/JSM-6610LV). The cookies were prepared and immersed in acetone for 24 hours, dried, and then analysed for both surface and cross-sectional views at magnification levels of ×500 and ×1,000, respectively.

Statistical analysis

The difference between the parameters of the different formulations of durian cookies were studied by one-way analysis of variance (ANOVA), with significant differences determined using Duncan's multiple range test (DMRT) (Watts *et al*., 1989).

Results

The formulation of durian cookies involved the substitution of wheat flour at four different concentrations (0%, 10%, 20%, and 30% w/w), as presented in Figure 1.

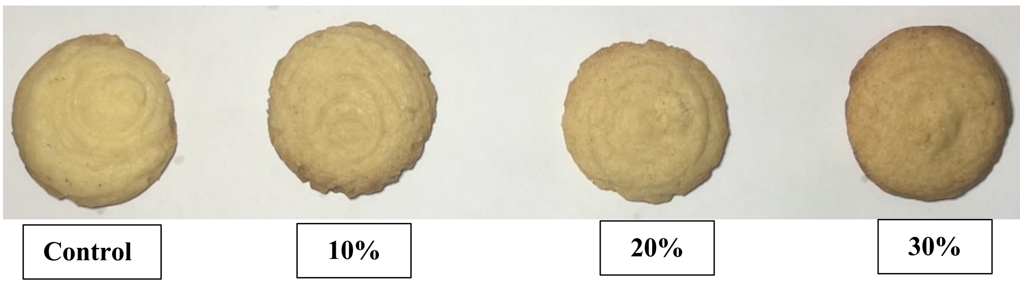

Figure 1. Images of durian cookies made using different concentrations of durian powder, with wheat flour being partially substituted at 0%, 10%, 20%, and 30%, respectively

Subsequently, the physicochemical properties of the four samples of durian cookies were determined, focusing on moisture content, hardness, and colour parameters, as displayed in Table 2.

Table 2. Physicochemical properties of four cookie formulations substituted with durian powder

Durian powder Concentration (%w/w)	Moisture Content (%)	Hardness (N)	Colour		
			L*	a* ns	b*
0	3.27±0.11[a]	27.04±2.13[b]	64.45±2.53[a]	8.97±1.49	21.77±1.99[a]
10	2.93±0.26[ab]	27.93±0.45[b]	62.12±1.55[ab]	9.31±1.04	19.89±0.54[ab]
20	2.93±0.12[ab]	28.94±0.81[ab]	62.04±1.07[ab]	8.83±1.02	20.31±1.22[ab]
30	2.87±0.16[b]	30.60±0.34[a]	62.26±2.11[b]	9.89±2.05	19.10±1.42[b]

L* (lightness) 0 = black, 100 = white, a* (redness/greenness) + = redness, - = greenness, b* (yellowness/blueness) + = yellowness, - = blueness, Each data represents the mean of three replications, Mean with different letters are statistically different ($p \leq 0.05$) according to Duncan's multiple range test.

The increasing concentration of durian powder is tended to reduce in the moisture content of durian cookies (Table 2). The durian cookies containing 30% w/w durian powder was significantly ($\rho \leq 0.05$) lowest in moisture content of 2.87±0.16%. On the contrary, the substitution of durian powder associated with an increase in the hardness of the cookies, with the highest hardness value of 30.60±0.34 N which observed in the cookies with the same 30% w/w durian powder substitution ($\rho \leq 0.05$). Furthermore, the substitution of durian powder resulted to decrease in both lightness (L*) and yellowness (b*), while the redness (a*) values increased. The significantly lowest values for lightness (L*) and yellowness (b*) were recorded at 62.26±2.11 and 19.10±1.42, respectively. Although the redness (a*) increased with higher concentrations of durian powder, this change was not statistically significant differed ($\rho \leq 0.05$). Overall, a higher concentration of durian powder leaded to cookies that are shown in darker, harder, and possess lower moisture content compared to those with lower concentrations.

For the caloric content, durian cookies were prepared using different concentrations of durian powder, with wheat flour being partially substituted at levels of 0%, 10%, 20%, and 30% w/w, respectively. The analysis of gross energy is shown in Figure 2. It was observed that higher levels of durian powder substitution led to decrease in the caloric content of the cookies. The lowest caloric value, which was statistically significant differed ($\rho \leq 0.05$) which recorded at the 30% w/w substitution level of durian powder.

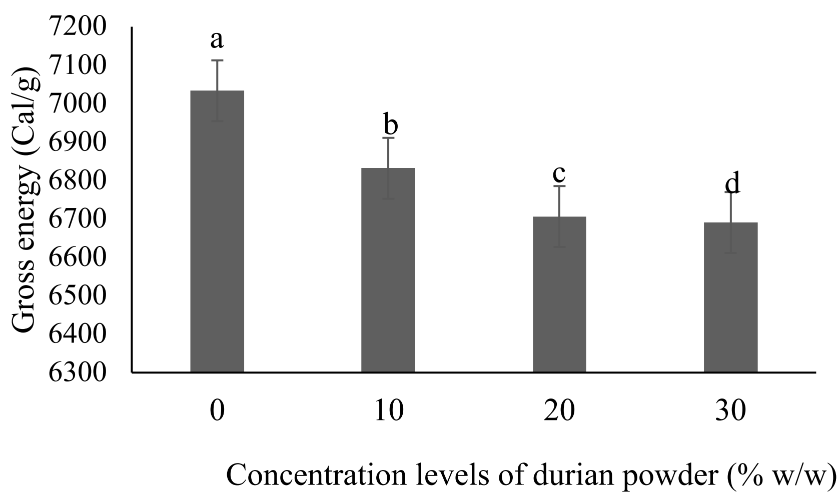

Figure 2. The gross energy of durian cookies made from different concentrations of durian powder, with wheat flour partially substituted at levels of 0%, 10%, 20%, and 30% w/w, respectively

Subsequently, the sensory properties of the four formulations of durian cookies were evaluated and illustrated in Table 3. The substitution of durian powder resulted to decrease in preference scores for colour, aroma, taste, and texture, which were significantly ($\rho \leq 0.05$) different from the control formulation. However, the formulation with 20% w/w durian powder was significantly exhibited the highest acceptability. Hence, this particular formulation of durian cookies was selected for further investigation into the effects of partially substituting sugar with inulin at levels of 0%, 20%, 40%, and 60% w/w. The results of the four formulations of durian cookies supplemented with inulin are shown in Figure 3.

Table 3. Sensory evaluation of four cookie formulations substituted with durian powders, as determined by 9-point hedonic scores

Durian powder concentration (%w/w)	**Preference Scores±Standard deviation**				
	Colour	**Aroma**	**Taste**	**Texture**	**Overall Acceptability**
0	7.37±1.09[a]	7.20±1.03[a]	7.47±1.07[a]	7.03±1.07[a]	.710±0.92[ab]
10	6.76±0.97[b]	7.10±1.03[a]	6.47±1.22[b]	6.83±1.09[a]	6.83±1.09[ab]
20	6.47±0.86[b]	6.67±0.99[a]	7.23±1.10[a]	7.00±0.98[a]	.727±0.91[a]
30	6.47±1.09[b]	6.43±1.50[b]	6.47±1.76[b]	6.17±1.23[b]	.653±1.25[b]

Mean with different letters are statistically different ($\rho \leq 0.05$) according to Duncan's multiple range test.

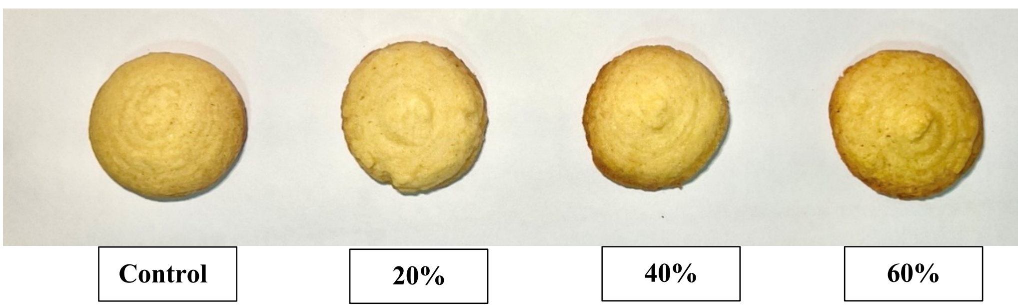

Figure 3. Images of durian cookies made with the supplementation of inulin, with sugar being partially substituted at 0%, 20%, 40%, and 60% w/w, respectively

The four formulations of durian cookies supplemented with inulin were evaluated for physicochemical properties, including moisture content, hardness, and colour parameters, as presented in Table 4. The supplementation of inulin is slightly increased in both moisture content and hardness. The highest value was shown in the durian cookies with a 60% w/w inulin replacement, which were 3.45±0.14% and 30.25±0.58N, respectively. However, these values were not significantly differed. On the other hand, the substitution of inulin appeared to reduce lightness (L*) and yellowness (b*), while increased in redness (a*). The durian cookies with 60% w/w inulin supplementation were significantly lowest values for lightness (L*) and yellowness (b*), recorded at 68.78±0.47 and 22.47±0.03, respectively. In contrast, the highest value for redness (a*) was significantly ($\rho \leq 0.05$) greater in the cookies with the same level of inulin supplementation.

Table 4. Physicochemical properties of four cookie formulations supplemented with inulin

Inulin Concentration (%w/w)	Moisture Content (%)^{ns}	Hardness (N)^{ns}	Colour		
			L*	a*	b*
0	3.05±0.30	29.96±0.04	73.89±1.14^{a}	8.57±0.03^{b}	24.10±0.71^{a}
20	3.02±0.43	29.95±0.07	71.63±0.45^{ab}	9.47±0.04^{a}	23.91±0.19^{ab}
40	3.12±0.48	30.19±0.90	69.92±2.35^{bc}	9.42±0.10^{a}	22.72±1.20^{bc}
60	3.45±0.14	30.25±0.58	68.78±0.47^{c}	9.49±0.73^{a}	22.47±0.03^{c}

L* (lightness) 0 = black, 100 = white, a*(redness/greenness) + = redness, - = greenness, b*(yellowness/blueness) + = yellowness, - = blueness,
Each data represents the mean of three replications., Mean with different letters are statistically different ($p \leq 0.05$) according to Duncan's multiple range test.

Then, the analysis of durian cookies, which were prepared using different concentrations of inulin with partial sugar replacement of 0%, 20%, 40, and 60% w/w, respectively was evaluated their gross energy, as shown in Figure 4.

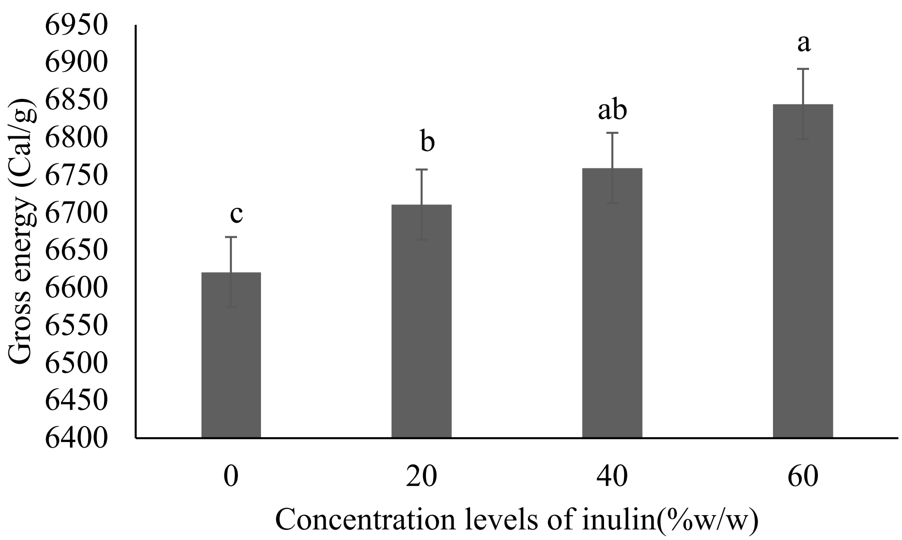

Figure 4. The gross energy of durian cookies made from different concentrations of inulin with partial replacement of sugar at 0%, 20%, 40%, and 60% w/w, respectively

Result indicated that a substantial concentration of inulin supplementation led to increase in the caloric content of durian cookies (Figure 4). The highest caloric value was significantly differed in the durian cookies that supplemented with 60% w/w inulin. Subsequently, four formulations of durian cookies with varying levels of inulin were subjected to sensory evaluation, with the findings detailed in Table 5.

It indicated that the supplementation of inulin influenced the preference scores related to colour, aroma, and texture (Table 5). For both colour and aroma, the preference scores was not significantly differed. However, durian cookies containing 20% w/w inulin supplementation was significantly increased in preference attributes concerning taste, texture, and overall liking. Consequently, this formulation of durian cookies is identified as a healthier option. Additionally, the caloric content of durian cookies supplemented with 20% w/w inulin was significantly lower than the control cookies, with caloric values recorded at 7033.99±1.25 and 6710.76±12.77 Cal/g, respectively as presented in Figure 5.

Table 5. Sensory evaluation of four cookie formulations supplemented with inulin, as determined by 9-point hedonic scores

Inulin Concentration (%w/w)	Preference Scores±Standard deviation				
	Colour^{ns}	Aroma^{ns}	Taste	Texture	Overall Acceptability
0	6.97±0.99	6.57±1.10	6.47±1.31^{ab}	6.63±1.16^{a}	6.57±1.04^{a}
20	6.93±0.91	6.53±0.89	6.90±1.16^{a}	6.50±1.28^{a}	6.77±1.10^{a}
40	6.77±0.94	6.43±1.61	6.57±1.01^{ab}	6.23±1.19^{ab}	6.70±0.79^{a}
60	6.50±1.14	6.33±1.58	6.17±0.99^{b}	5.77±1.07^{b}	.603±1.03^{b}

Mean with different letters are statistically different (ρ≤0.05) according to Duncan's multiple range test

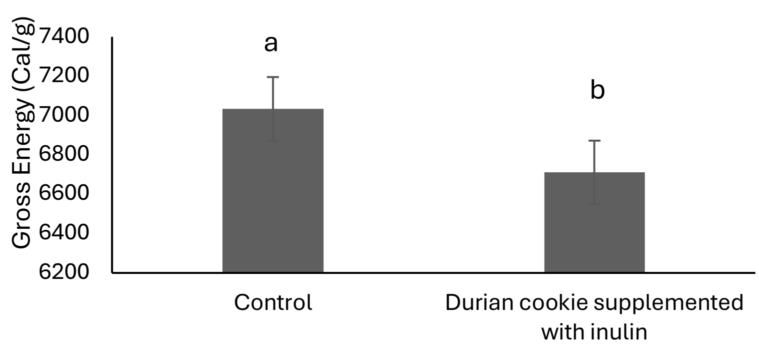

Figure 5. The gross energy of durian cookies supplemented with 20% w/w inulin as compared with the control cookie

Lastly, the microstructure of four formulations of durian cookies supplemented with inulin was examined using a scanning electron microscope. This analysis focused on both the surface and cross-section at magnifications of 500x and 1,000x, as illustrated in Figures 6 and 7, respectively.

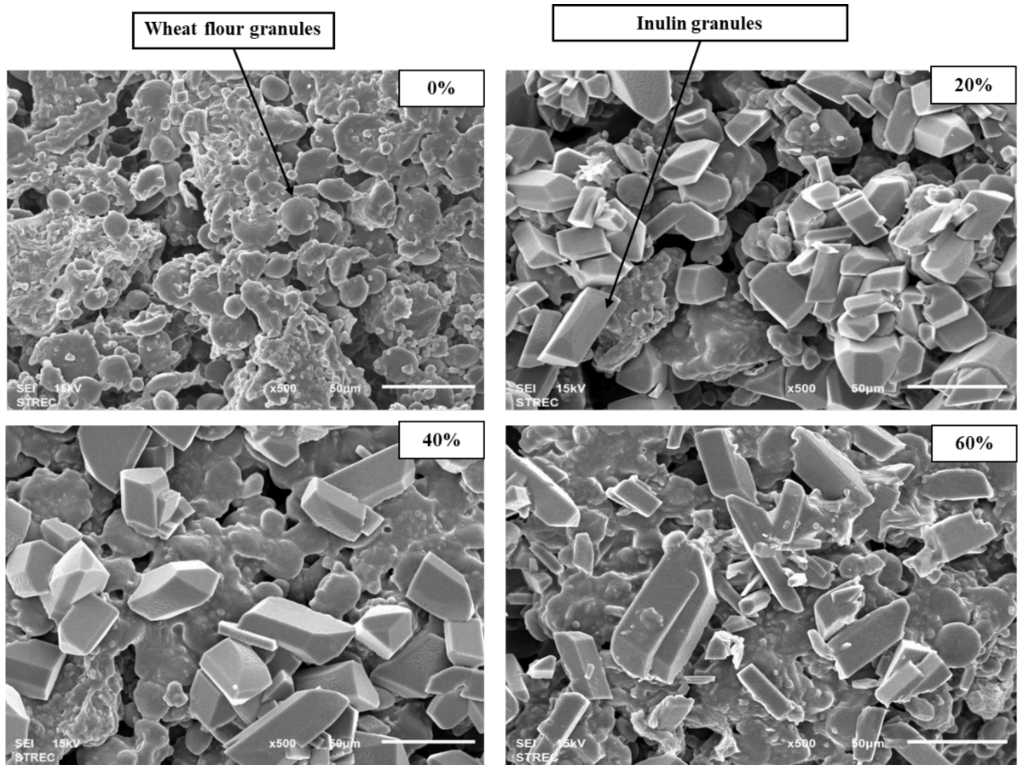

Figure 6. Scanning Electron Micrographs depicting the surface of durian cookies made with varying concentrations of inulin, incorporating partial sugar replacement at levels of 0%, 20%, 40%, and 60% w/w, respectively

It revealed that the microstructural examination demonstrated a well-formed protein network matrix, with the starch granules (round shape) maintaining their integrity in the control cookies containing 0% inulin. In contrast, the presence of inulin was observed in the durian cookies with 20%, 40%, and 60% supplementations, both on the surface and within the cross-section. The inulin is contributed to the formation of a gel network within the durian cookies at the 40% and 60% substitution levels (Figure 7).

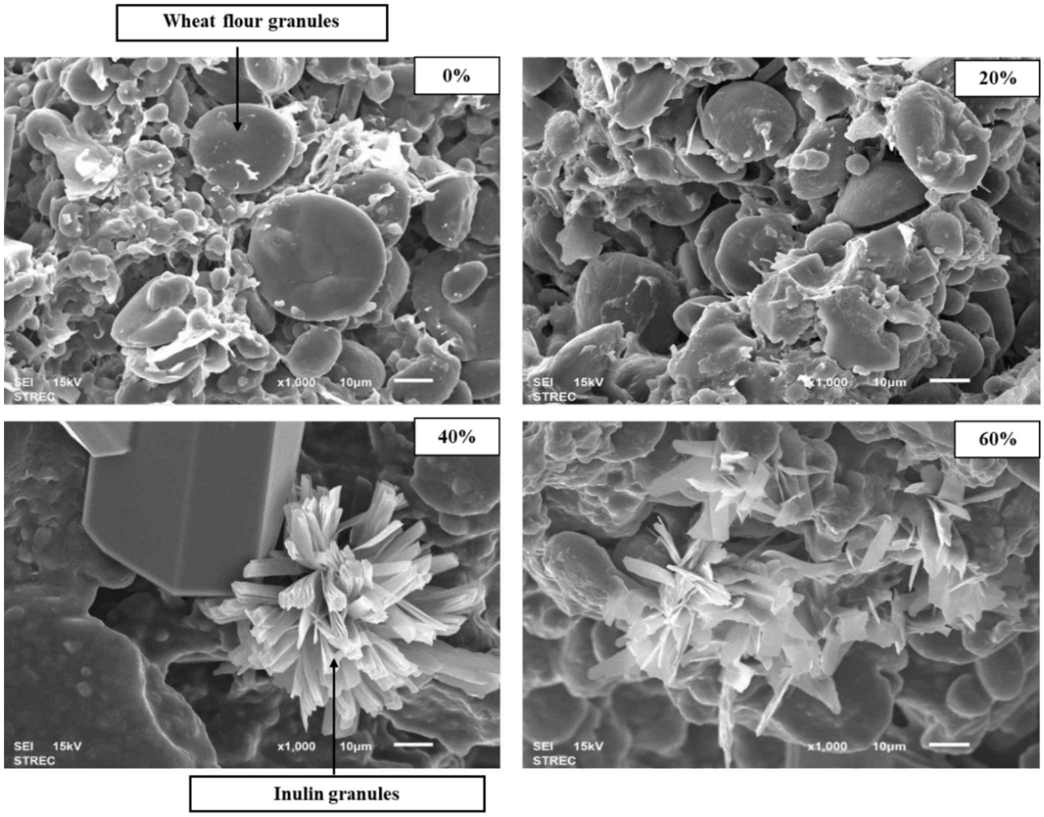

Figure 7. Scanning Electron Micrographs depicting the cross-section of durian cookies made with varying concentrations of inulin, incorporating partial sugar replacement at levels of 0%, 20%, 40%, and 60% w/w, respectively

Discussion

Cookies were developed using four different substitution levels of wheat flour (0%, 10%, 20%, and 30% w/w) with durian powder and examined for various physicochemical properties, including moisture content, hardness, colour parameters, and caloric value. The findings revealed that the substitution of durian powder led to decrease in moisture content, while the hardness of the cookies increased. This could be attributed to the low moisture content (3.05±0.65%) inherent in the durian powder, suggesting that the reduction in moisture content is contingent upon the proportion of durian powder utilized.

The substitution of durian powder leaded to decrease in lightness (L*) and yellowness (b*), while simultaneously increasing redness (a*). A higher concentration of durian resulted in darker and harder cookies, which exhibited lower moisture content in comparison to lower concentration. This could be attributed to the intensified caramelization and Maillard reactions that occur during the baking process, resulting in enhanced a surface browning (Blanco *et al.*, 2017). Moreover, the substitution of durian powder is diminished the gluten network within the dough, consequently leading to increase in hardness that correlates with the concentration of durian powder used.

In the investigation of caloric content, it was observed that higher concentrations of durian powder tended to decrease the caloric value of durian cookies. The lowest gross energy was significantly differed which recorded at a 30% w/w substitution of durian powder. g the sensory evaluation, the substitution of durian powder is negatively impacted the preference scores for colour and aroma, with significant differences ($\rho \leq 0.05$) noted when compared to the control formula. Nevertheless, a 20% w/ w substitution of durian powder was significantly highest in acceptability, likely due to the overpowering aroma associated with higher concentrations. Consequently, consumer preferences varied leading to further exploration of a durian cookie formulation that is partially replaced sugar with inulin at levels of 0%, 20%, 40%, and 60% w/w, respectively.

The findings indicated that the supplementation of inulin led to increase in both moisture content and hardness. These observations aligned with the research conducted by Maghaydah *et al.* (2013), which demonstrated that cookies exhibited the highest moisture content with a 4% inulin supplementation. This could be attributed to the properties of inulin (a soluble fiber), which enhances its solubility at elevated temperatures. During the baking process, it appears that the fructan chains of inulin gradually dissolve and break down, resulting in the formation new low- molecular-weight compounds, thereby contributing to the observed increases in moisture content and hardness (Lee *et al.*, 2017). Furhtermore, similar findings were reported in a prior study by Blanco s *et al.* (2017), which noted that at 12% addition of inulin also augmented the hardness of biscuits. The increase in the inulin network reveals more compact network structure (Glibowski and Wasko, 2008).

Conversely, the supplementation of inulin appeared to reduce in lightness (L^*) and yellowness (b^*), while increased in redness (a^*). These findings are consistent with those reported by Morris and Morris (2012), who noted a darker crust colour across all substitution levels (2.5%, 5%, and 7.5%) of two types of inulin. This could be attributed to the interaction of fructan chains in inulin with other ingredients, facilitating the caramelization process and Maillard reaction during the baking, which is influenced by the quantity of inulin incorporated (Blanco *et al.*, 2017).

On the other hand, the supplementation of inulin at a high concentration influenced the caloric content of durian cookies. The highest caloric value was significant observed in the cookies supplemented with 60% w/w inulin. Traditionally, substituting sugar with inulin is expected to be a lower caloric count, as noted in previous research (Shoaib *et al*., 2016). Nevertheless, the findings of this study indicated a contrary outcome, suggesting that inulin may also modify the interactions among other ingredients, such as sugars and fats. This alteration could affect the absorption and utilization of these ingredients during the baking process, thereby impacting the overall caloric value of the cookies (Blanco *et al.,* 2017). Despite this, the durian cookies are still exhibited a lower caloric content when compared to the control cookie formulation.

The supplementation of inulin resulted to decrease in the preference scores for colour, aroma, and texture. For both colour and aroma, the preference scores was not significantly differed. However, durian cookies supplemented with 20% w/w inulin was significantly higher preference ($\rho \leq 0.05$) for taste, texture, and overall liking. These findings aligned with those reported by Giarnetti *et al.* (2015), which indicated that cookies made with inulin also displayed a poorer sensory property as compared to control cookies. Hence, the formulation for the durian cookies is identified as a healthier option. Interestingly, the caloric content of the newly developed durian cookies was significantly lower ($\rho \leq 0.05$) than that of the control. Furthermore, the microstructural analysis of four formulations of durian cookies with inulin was focused on both surface and cross-sectional views. The observations revealed that the protein network matrix was well-formed, and the wheat flour granules remained largely intact in the control durian cookies. In contrast, the inulin molecules formed a gel network in the durian cookies supplemented with 20%, 40%, and 60% inulin, evident in both surface and cross-sectional analyses. These results aligned with the observations made by Lee *et al.* (2017), who identified a similar microstructural composition in cookies that incorporated inulin.

In conclusion, the findings of the study indicated that varying concentrations of inulin substitution led to increase in moisture content, hardness, redness (a*), and calories, while simultaneously resulting to decrease in lightness (L*) and yellowness (b*). For the sensory evaluation, a 20% w/w inulin supplementation yielded the highest preference scores for taste, texture, and overall liking. Interestingly, the cookies formulated with durian was significantly lower caloric content as compared to the control cookies. Thereby, these cookies can be regarded as a source of dietary fiber due to the inclusion of inulin, which is associated with numerous health benefits. It is anticipated that these cookies would meet the expectation of future consumers. Furthermore, the development of these healthily would be enhance the durian cookies for food manufacturers to offer healthier dietary options and currently underrepresented in the market. This initiative could also serve as an add value to low-grade durian pulp of low standard quality criteria.

Acknowledgments

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References

Abed, S., Ali, A. H., Noman, A., Niazi, S., Ammar, A. F. and Bakry, A. M. (2016). Inulin as prebiotics and its application in food industry and human health; A review. International Journal of Agriculture Innovations and Research, 5:88-97.

Akram, W., Garud, N. and Joshi, R. (2019). Role of inulin as prebiotics on inflammatory bowel disease. Drug Discoveries & Therapeutics, 13:1-8.

Aziz, N. A. and Jalil, A. M. M. (2019). Bioactive compound, nutritional value, and potential health benefits of indigenous durian (*Durio Zibethinus* Murr.): A review. Foods, 8:1-18.

Blanco Canalis, M. S., León, A. E. and Ribotta, P. D. (2017). Effect of inulin on dough ang biscuit quality produced from different flours. International Journal of Food Studies, 13-23.

Charoenphun, N. (2018). Development of cookie products from sweet potato, Journal of food technology,Siam university, 13:32-43.

Charoenphun, N. and Kwanhian, W. (2019). Production of Gluten Free Cookies Supplemented with Durian Rind Flour. Science and Technology RMUTT Journal, 9:23-38.

Charat, R., Lertsiri, S. and Tananuwong, K. (2022). Volatile compound production and quality characteristics of Durian fruit cv. Mongthong as affected by 1-methylcyclopropene and modified asmosphere storage. International Journal of Friut Science, 22:481-494.

Devalaraja, S., Jain, S. and Yadav, H. (2011). Exotic fruits as therapeutic complements for diabetes, obesity and metabolic syndrome. Foos Research International, 44:1856-1865.

Dharma, A. and Insani, R. M. S. (2020). Development of Healthier Cookie Product by Utilizing Different Formulations of Durian Seed Flour. Indonesian Journal of Life Sciences, 02:89-95.

Duncan, M. (2011). Mauley's technology of biscuits, crackers and cookies. Cambridge: Woodhead Publishing Series in Food Science, Technology and Nutrition: Number, 217.

Giarnetti, M., Paradiso, V. M., Caponio, F., Summo, C. and Pasqualone, A. (2015). Fat replacement in Shortbread cookies using an emulsion filled gel based on inulin and extra virgin olive oil. LWT – Food Science and Technology, 63:339-345.

Glibowski, P. and Wasko, A. (2008). Effect of thermochemical treatment on the structure of inulin and its gelling properties. International Journal of Food Science and Technology, 43:2075-2082.

Kolida, S., Tuohy, K. and Gibson, S. R. (2002). Prebiotic effects of inulin and oligofructose. British Journal of Nutrition (Suppl.), 2:s193-197.

Lee, Y. J., Lee, O. H. and Yoon, W. B. (2017). Effect of inulin Jerusalem artichoke (Helianthus tuberosus l.) flour on the Viscoelatic behavior of cookie dough and quality of cookie. Proceedings of the Internation Food Operation and Processing Simulation Workshop. p. 35-44.

Maghaydah, S., Abdul-Hussain, S., Ajo, R., Odeidat, B. and Tawalbeh, Y. (2013). Enhancing the Nutritional Value of Gluten – Free Cookies with Inulin. Advance Journal of Food Science and Technology, 5:866-870.

Mahyiddin, Z., Indani, Suhairi1, L, Ulya, Z. and Munanda, Z. (2020). The addition of nutmeg (*Myristica fragrans*) essential oil to intensify the aroma as a replacement of rum considering halal supply chain for cookies that use durian (*Durio zibethinus*) seeds waste-based flour to create sustainable advantages. IOP Conf. Series: Earth and Environmental Science, 956:012007.

Morris, C. and Morris, G. A. (2012). The effect of inulin and fructo-oligosaccharide supplementation on the textural, rheological and sensory properties of bread and their role in weight management: A review. Food Chemistry, 133:237-248.

Pertiwi, E. D., Wijaningsih, W. and Tursilowati, S. (2018). Protein Fat, Carbohydrates and the Acceptance Level toward Durian Seed Flour Cookies. ARC Journal of Nutrition and Growth, 4:2455-2550.

Robert, S. D., Ismail, A. A. S., Winn, T. and Wolever, T. M. (2008). Glycemic index of common Malaysian fruits. Asia Pacific Journal of Clinical Nutrition, 17:35-39.

Shoaib, M., Shehzad, A., Omar, M., Rakha, A., Raza, H., Sharif, H. R., Shakeel, A., Ansari, A. and Niazi, S. (2016). Inulin: Properties, health benefits and food applications. Carbohydrate Polymers, 147:444-454.

Suppramaniam, H., Hussin, N. and Jalil, A. M. M. (2019). Glycaemix index, palatability, acceptability and perceived satiety of cookies prepared with durian (Durio Zibethinus Murr) and β-glucan. Malays. Annals of Apply Biology, 48:89-99.

Tan., C. H., Ishak, W. R. W., Easa, A. M., Hii, C. L., Chuo, K. M. J., How, Y. H. and Pui, L. P. (2023). From waste to wealth: a review on valorisation of durian waste as functional food ingredient. Journal of Food Measurement and Characterization,17:6222-6235. ·

Thammarutwasik, P., Hongpattarakere, T., Chantachum, S., Kijroongrojana, K., Itharat, A., Reanmongkol, W., Tewtrakul, S. and Ooraikul, B. (2009). Prebiotics-A review. Songkranakarin Journal of Science and Technology, 31:401-408.

Watts, B. M., Yumaki, C. L., Jeffery, L. E. and Elais, L. G. (1989). Basic sensory methods for food evaluation. International Development Research Centre, Ottawa, Canada. p.159.

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