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Improving Sweet Bread Properties with Diacetyl Tartaric Acid Ester of Monoglyceride (DATEM)

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Abstract

Diacetyl Tartaric Acid Ester of Monoglyceride (DATEM) has been used in bread making to improve its dough and final product properties. The efficiency of DATEM in bread with the presence of sugar is yet to be studied. Therefore, this study aims to examine the effects of DATEM addition on sweet bread properties, i.e., its moisture content, loaf volume expansion, porosity and organoleptic properties. Completely Randomized Design (CRD) was employed with 5 treatments and 4 replications. The variables were the addition of DATEM, i.e., 0%, 0.15%, 0.3%, 0.45%, 0.6% (w/w) of the total flour. The data were analyzed using Analysis of Variance (ANOVA) with the significance level of 5%. The study showed that DATEM significantly impacts the physical and organoleptic properties of sweet bread. As DATEM concentration increases, so does moisture content, porosity, and loaf volume. Consequently, the texture becomes softer, and fewer crumbs are produced. Overall, DATEM enhances sweet bread properties, with 0.6% concentration yielding the best results. Sweet bread with 0.6% DATEM exhibited 34.05% moisture content, 76.86% loaf volume expansion, and 3.38 mm porosity.

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Introduction

Bread is enjoyed by consumers worldwide in different versions and tastes such as plain or sweet breads. Sweet breads are bakery products which have a higher sweetness than that of white bread; its texture is soft and can be added with jam, chocolate or other type of fillings according to the consumer preference (Calligaris et al., 2013). Sweet breads consumption in Indonesia is about three times higher than plain/ordinary bread with the average per capita consumption of 1044 pieces in 2022 (Ministry of Agriculture, 2022). Due to the high popularity of sweet bread, bakers are required to produce high-quality products.

One of the main problems often faced by bakers is bread failing to rise in volume during baking, which significantly affects its physical quality (Pareyt et al., 2011). The failure or low rising of bread can be caused by several factors such as low yeast quality, improper addition of salt, incorrect proofing technique, or insufficient kneading (Mathuravalli, 2021). Additionally, low rising bread can also result from suboptimal interactions between ingredients. For example, the dough quality will be inferior if the oil and water-based ingredients do not mix properly. Thus, emulsifying agents can be added to dough mix in order to improve physical properties of bread (Rosell et al., 2001). An emulsifier has two parts that is hydrophilic part and lipophilic part which is able to form or maintain a homogenous mixture of two immiscible phases such as oil and water so it will make the dough more stable (Basuki et al., 2013). An example of natural emulsifier added in bread making is egg yolk whereas some popular artificial options include lecithin, glycerol monostearate and DATEM. The emulsifiers commonly used in bread are lecithin and egg yolks. However, they are often required in high concentrations, which is considered ineffective for keeping production costs low (Setyawan, 2018).

DATEM is an artificial emulsifier with a high Hydrophilic-Lipophilic Balance (HLB) value of 9.2 (Eduardo et al., 2014). An emulsifier with an HLB value of 8-18 indicates that it is soluble in water and can improve oil-in-water emulsions. A high HLB value also indicates that the emulsifier can be used in low concentrations while still effectively increasing the volume of bread (Adisalamun et al., 2012). DATEM has been employed in bread quality improvements, for instance, in whole wheat bread (Tebben et al., 2018), steamed bread with potato pulp (Cao et al., 2021), frozen rice wine dough (Ma et al., 2024), and low gluten bread from sorghum (Sharanagat et al., 2022). However, to the best knowledge of the authors, the use of DATEM to improve the characteristics of sweet bread made from wheat flour has not been reported.

According to the National Agency of Drug and Food Control (BPOM) of the Republic of Indonesia regulation number 11 of 2019 regarding the maximum use of additives, the limit for using DATEM in bakery products, white bread, and premixes is 6 g/kg (0.6%) (BPOM, 2019). Therefore, the current study aims to evaluate the effects of adding DATEM as an emulsifier on moisture content, loaf expansion volume, porosity, and to determine the optimum concentration of DATEM for producing sweet bread preferred by consumers.

Materials and Methods

Materials

The main ingredients used in this study are high-protein wheat flour (Cakra Kembar, Bogasari, Indonesia), DATEM (DuPont, Grindsted, Denmark), yeast, sugar, salt, shortening, water, calcium propionate, and ascorbic acid. The equipment used includes beaker glass, an analytical balance (Excellent DJ Series), bowl mixer, oven, proofer machine, spatula, plastic wrap, a set of tools for moisture content analysis, a caliper to measure loaf volume, and a ruler to measure bread porosity.

Methods

The research procedures involved the process of making sweet bread, referring to Halim et al., (2015) with modifications, and measurements of the moisture content, loaf expansion volume, and porosity of the sweet bread.

The Production of Sweet Bread

Wheat flour (54.7%), sugar (5.5%), and calcium propionate were mixed together in a mixer bowl until thoroughly combined. DATEM was then added at concentrations of 0%, 0.15%, 0.3%, 0.45%, and 0.6% (w/w flour base), followed by the addition of water containing yeast and ascorbic acid to the mixer bowl. The dough was mixed at low speed for 3 minutes. Subsequently, shortening and salt were added to the mixer bowl, and mixing continued at medium speed for 3 minutes, followed by high speed for 10 minutes until the dough was completely mixed and smooth.

The dough was shaped into rounds and moved to the baking pan, then covered with fabric for 20 minutes (first proofing process). After proofing, the dough was weighed and shaped into half balls (55g for 1 piece of sweet bread) and placed on a baking pan. The next stage was the proofing process, where the baking pan was placed into a proofing machine with a temperature of 38°C and relative humidity (RH) of 80% for 90 minutes. The final stage was the baking process, where the dough was baked in an oven at a temperature of 180°C for 10 minutes.

Moisture Content (AOAC, 2005)

Moisture content was measured using a porcelain cup dried in an oven for 60 minutes at a temperature of 105°C. After cooling in a desiccator for 10 minutes, the cup was weighed (A). Samples with specific weights (B) were then placed in the porcelain cup. The cup and its contents were dried in an oven at 105°C for 5 hours, then cooled in a desiccator for 15 minutes, and weighed (C). The moisture content of the sample can be calculated by the following equation:

$$Moisture\ Content\ (\%) = \frac{(C - A)}{(B - A)} \times 100\%$$

where the dry weight of the cup (A), the weight of the cup and its contents after drying (C), and the weight of the sample (B) are used to calculate the moisture content in percentage.

Loaf Volume Expansion (Surono et al., 2017)

The volume of the bread (*V*) was calculated using the formula for the volume of a spherical segment of a ball.

$$V = \frac{1}{3}\pi h^2(3r - h)$$

It was calculated from the height (*h*) and radius (*r*) of the dough before the proofing process and after the baking process. The next step involved calculating the loaf volume expansion by using the difference between the volume of the dough before proofing and after baking (the bread). The loaf volume expansion (LVE) can be calculated by the following equation:

$$LVE\ (\%) = \frac{Bread\ Vol - Dough\ Vol}{Dough\ Volume} \times 100\%$$

Bread Porosity (Surono et al., 2017)

The porosity of the bread was measured by cutting a piece of bread (crumb) with a size of 3x3 cm and dividing it into 4 sections. Any pores visible to the naked eye in each section were marked, and the diameter of each pore was measured. The diameter of all pores were accumulated, and the average value of the diameters (in millimeters) was calculated.

Data Analysis

The data were analyzed using the SPSS 16.0 application at a significance level of 95% ($p \leq 0.05$). Analysis of the data on moisture content, loaf volume expansion, and porosity used the Analysis of Variance (ANOVA) parametric test, followed by Duncan's multiple test. The analysis of data from the organoleptic test used the Kruskal-Wallis test, followed by the Mann-Whitney Test.

Results and Discussion

Moisture Content

The trend of moisture content in sweet bread as affected by different DATEM concentration can be seen on Figure 1. DATEM addition has a significant effect ($p < 0.05$) to the moisture level of sweet bread where moisture content increases as the DATEM concentration getting higher. The highest moisture content (34.05%) was observed in the sweet bread with addition of 0.6% DATEM (w/w flour base). However, this value was not significantly different from the treatment with 0.45% DATEM.

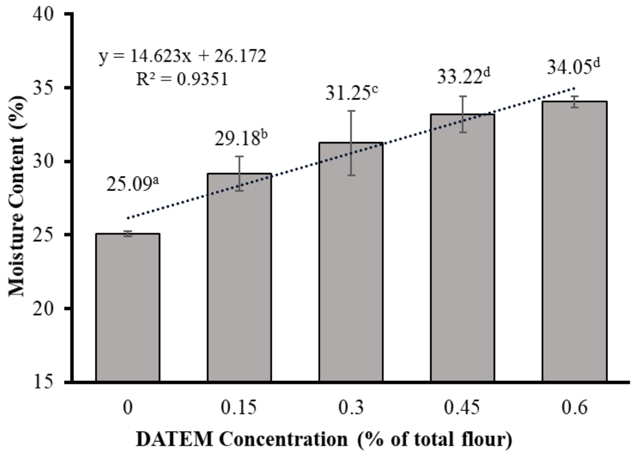

Figure 1. Moisture content of sweet bread as affected by the addition of DATEM. Data labels are shown as means, whereas standard deviations are shown as error bars. Different superscript letters indicate statistically significant differences ($p < 0.05$).

The increasing moisture content can result from the emulsifier effect, which enables better water binding due to its hydrophilic part. This is in accordance with Latifah et al*.* (2017), who state that emulsifiers can increase the water absorption capacity of dough, thereby affecting its moisture content. Bread with added emulsifier has a higher moisture content than bread without emulsifier. The level of hardness in bread can also be affected by moisture content. Syahputri and Wardani (2014) state that dough with good water-binding capacity will produce an elastic dough that easily expands, resulting in softer bread.

The moisture levels of sweet bread in the current study were in accordance with the Indonesian National Standard (SNI) for sweet bread from 1995, which stipulates that moisture must be below 40%. If the bread has a high-moisture content, it will be easily damaged and become stale quickly. Based on the linear trendline $y=14.623x+26.172$ (Figure 1), we can calculate that the usage of emulsifier resulting in a maximum moisture content of 40% is 0.94% DATEM (on a flour basis). However, this equals 9.4 g of DATEM per 1000 g of flour, which exceeds the regulatory limit of 6 g/kg of materials. Therefore, the usage of DATEM up to the maximum permissible limit in sweet bread is safe concerning moisture content.

Loaf Volume Expansion

As can be seen in Figure 2, the average loaf volume expansion in sweet bread increases with the increasing DATEM concentration. The expansion trend follows linear equation of $y = 28.758x + 60.376$. The test results using ANOVA showed a significant effect ($p < 0.05$) on the differences in the addition of DATEM to the loaf volume. The highest loaf volume was observed with the addition of 0.6% DATEM (of flour base), reaching 76.86%, but this treatment did not show a significant effect compared to the addition of 0.45% DATEM ($p > 0.05$).

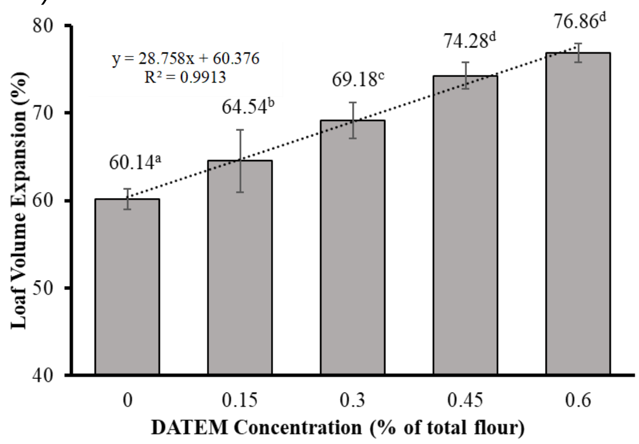

Figure 2. Loaf volume expansion of sweet bread as affected by the addition of DATEM. Data labels are shown as means, whereas standard deviations are shown as error bars. Different superscript letters indicate statistically significant differences ($p < 0.05$).

The increased loaf volume indicates that the emulsifier helps the dough expand more easily, thereby increasing the volume of the bread. This is supported by Pane et al*.* (2012), who stated that the addition of an emulsifier makes the dough more thoroughly mixed due to the hydrophilic and lipophilic parts binding water and oil, respectively, resulting in a more stable and easily expanded dough. Additionally, Damat et al*.* (2017) noted that emulsifiers enhance the dough's ability to trap fermentation gases, which increases the bread volume. The expansion of the dough occurs due to the fermentation process performed by yeast, which produces CO_2 gas that gets trapped in the dough, causing it to expand. This is consistent with Saepudin et al. (2017), who stated that the presence of water and sugar in the dough causes yeast to grow and convert sugar into CO_2 gas. The gas is trapped in the dough, making it expand and increasing the bread's volume.

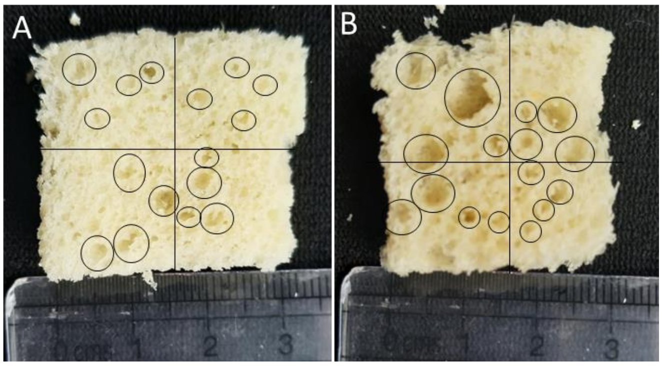

Figure 3. Bread porosity measurement of sweet bread. Shown in picture: A. without DATEM addition and B. with 0.6% DATEM addition.

Bread Porosity

Figure 3 shows the visual of bread pores and illustrates the measurement of bread porosity using a ruler. The porosity (expressed as the average diameter of pores) of sweet bread as affected by the addition of DATEM is shown in Figure 4. The addition of DATEM as an emulsifier shows a significant effect ($p < 0.05$) on bread porosity, with pore size increasing with higher DATEM concentrations following a linear trendline of $y = 3.2222x + 1.3333$. The highest porosity was observed with the addition of 0.6% DATEM (w/w flour base), with an average pore size of 3.38 mm. The bread porosity measurements indicated that the addition of DATEM increased pore size, corresponding to higher loaf expansion volume (Figure 2).

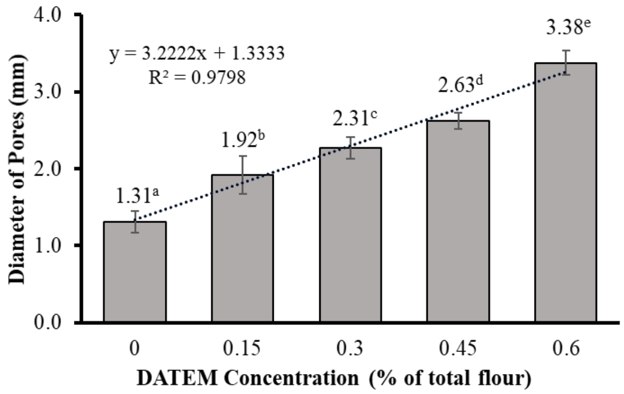

Figure 4. Bread porosity of sweet bread as affected by the addition of DATEM. Data labels are shown as means, whereas standard deviations are shown as error bars. Different superscript letters indicate statistically significant differences ($p < 0.05$).

According to Surono *et al.* (2017), bread pores are classified as large if their diameter is > 2 mm, medium if 1 mm – 2 mm, and small if < 1 mm. Large pores indicate that the bread can expand properly. They also state that the addition of emulsifier in bread dough produces a more stable, stronger dough that can prevent CO_2 gas from escaping. Damat et al. (2017) support this by noting that emulsifiers stabilize the dough by binding the two immiscible phases within it, resulting in a more stable and completely mixed dough. It is worth noting that the increase in bread volume and porosity may not always be regarded positively by consumers, as bread with very large pores may be considered "hollow" and perceived as poor quality. Thus, to obtain the best bread porosity properties, bakers must optimize the yeast and emulsifier amounts, combine them with good kneading and proofing steps, and, importantly, follow up with hedonic or consumer preference tests.

Textural Properties

The organoleptic properties of sweet bread with varying concentrations of DATEM were evaluated by a ranking test with 25 panelists (Figure 5). The results show that the addition of DATEM as an emulsifier has a significant effect ($p < 0.05$) on the texture (both on hand and mouthfeel) and crumb properties. The average scores for both on hand and mouthfeel texture decrease with higher concentrations of DATEM, indicating that DATEM makes the bread texture softer and more tender. The softest texture was found with 0.6% DATEM (w/w flour base) for both texture parameters. This is supported by Damat et al. (2017), who stated that the addition of an emulsifier forms a complex bond with the starch polymers amylose and amylopectin. This bond inhibits the process of starch retrogradation, softens the crumb, and delays bread staling. The hydrophilic structure of the emulsifier binds with water, maintaining moisture within the crumb, which produces a crumb with good properties and a soft texture. These results are in good agreement with Figure 1, which shows higher water binding properties with higher emulsifier concentration, thus corresponding to better crumb properties.

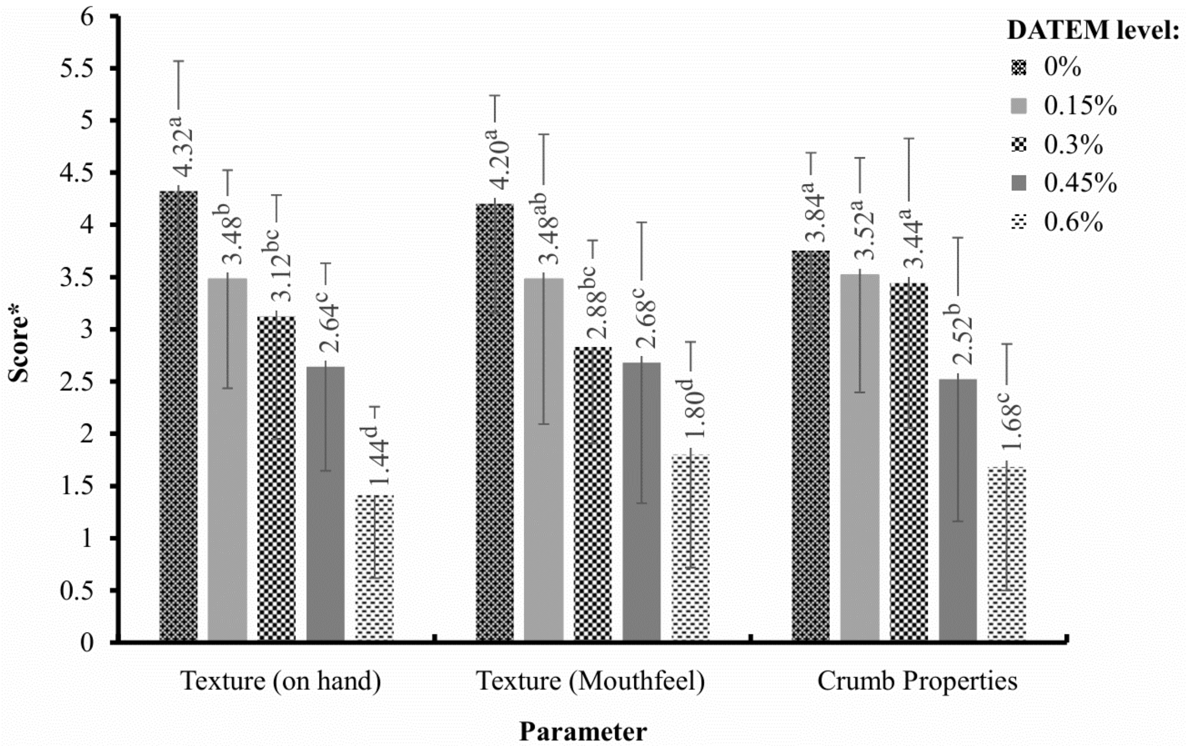

Figure 5. Organoleptic ranking of sweet bread as affected by the addition of DATEM. Data labels are shown as means, whereas standard deviations are shown as error bars. Different superscript letters within the same category parameter indicate statistically significant differences ($p < 0.05$). *Score description: Texture (1 = Softest, 5 = Hardest), Crumb Properties (1 = Lowest amount of breadcrumbs, 5 = Highest amount of breadcrumbs).

The trend in texture properties can also be linked to volume expansion and bread porosity (Figures 2 and 4). The addition of DATEM emulsifier produces bread with good volume and pore structure, which is eventually perceived as soft or tender by the panelists. Bread with good properties typically has a soft texture and is easy to chew. Eduardo et al. (2014) stated that bread that does not expand properly will have lower tenderness due to smaller pores, making the bread appear smaller and less acceptable to consumers.

Crumb Properties

The scores of crumb properties in Figure 5, which obtained by ranking test with 25 panelists, show a significant effect ($p<0.05$) with the addition of DATEM as emulsifier. The data in Figure 5 also showed that the average scores of crumb properties increased according to the treatment where the highest value is found with the addition of 0.6% DATEM (of flour base). The high score of crumb properties showed that the bread was not easy to produce bread crumbs.

One of the characteristics of a good bread is not easy to produce bread crumbs when the bread is cut (Arif, 2019). The dough stability is very important to determine the properties of bread crumb. The addition of emulsifier into the dough will make it more stable because the emulsifier is capable to bind the two immiscible phases on dough so it will evenly mixed. This is in accordance with the opinion of Cao et al. (2021) which states that the addition of emulsifier can strengthen the gluten network and will raise the dough stability in terms of trapping the fermented gas. The stronger bonding of dough gluten network then the stronger texture and less bread crumbs are produced.

The crumb properties evaluation was obtained from a ranking test with 25 panelists. It shows that the addition of DATEM as an emulsifier significantly affects ($p < 0.05$) sweet bread properties (Figure 5). Although adding DATEM up to 0.3% did not significantly impact bread crumb properties, the addition of 0.45% and 0.6% did, with the latter perceived to have the lowest score (indicating the least amount of breadcrumbs upon cutting). This result suggests that better crumb properties are obtained with increasing DATEM concentrations.

One of the characteristics of good bread is that it does not easily produce bread crumbs when cut (Arif, 2019). Dough stability is crucial in determining the properties of bread crumb. Adding an emulsifier to the dough enhances its stability by binding the two immiscible phases, ensuring a more even mix. This aligns with Latifah et al. (2017), who state that emulsifiers can strengthen the gluten network and increase dough stability by trapping fermented gas. A stronger gluten network results in a more resilient texture and fewer bread crumbs.

Conclusion

The current study has shown that the use of DATEM as an emulsifier significantly affects the physical and organoleptic properties of sweet bread. Increasing concentrations of DATEM result in higher moisture content, greater porosity, and a larger loaf volume expansion. Correspondingly, the texture of sweet bread becomes softer, both in on-hand and mouthfeel measurements, with higher DATEM concentrations. Additionally, higher DATEM concentrations produce fewer crumbs, a desirable characteristic in sweet bread. Therefore, the addition of DATEM generally improves sweet bread properties, with 0.6% DATEM showing the best results in this study. It is worth noting that this concentration is within the permissible level (max 0.6%) stipulated by the National Agency of Drug and Food Control of the Republic of Indonesia. Future studies on DATEM utilization in bread making should include hedonic or consumer preference tests to evaluate the optimal DATEM addition.

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