



The Effect of Palm Sap Substitution on Sandwich Bread Characteristics

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Abstract

Purpose of the study: This research was conducted to investigate the potential of palm sap locally known as legen water as a substitute for instant yeast, commonly used as a leavening agent in sandwich bread production.

Design/methodology: The research employed an experimental method. A hedonic test utilizing a 9-point likeness scale was administered to panelists through questionnaires. The palm sap used in this study was 3-4 hours old and collected during the evening tapping session.

Findings: Legen water tapped from the siwalan tree (*Borassus flabellifer*) during afternoon tapping can replace the role of instant yeast and affect the color, taste, texture, and aroma of sandwich bread products and also provide its own characteristics to the product.

Research limitations/Implication: The results of this research will be useful for traditional bread entrepreneurs because the instant yeast that is usually used can be replaced with legen water which is widely available in East Java region.

Novelty/Originality of the study: This research contributes to the understanding of alternative leavening agents in bread production and explores the potential applications of palm sap in food technology.

INTRODUCTION

Sandwich bread is a popular and beloved type of bread worldwide, known for its soft, fluffy, hollow texture and large volume. Bread main ingredients include high-protein wheat flour, water, salt, baker's yeast, fat, sugar, and baking ingredients (Aldi, 2023). Sandwich bread or often known as white bread has a definition as one of the bread products that can be said to be popular among Indonesian citizens, especially the younger generation who often adapt western culture who like to consume white bread as their breakfast choice. According to a study conducted by the Center for Agricultural data and Information System, Ministry of Agriculture in 2024, per capita consumption of white bread in Indonesia increased by around 15%. This increase was especially seen in urban areas, where consumption of white bread grew faster than in rural areas. Meanwhile, a report from the Indonesian Bakery Entrepreneurs Association (APEBI) in 2022 showed that sales of white bread in modern markets increased by around 8-10% per year during the 2018-2022 period This increase was driven by product innovation, such as white bread with various flavors and white bread enriched with additional nutrients (Septyan, 2022).

Good sandwich bread should have a large volume, soft, evenly hollow texture, good taste, bright crumb color, and a long shelf life. Proper packaging is essential for maintaining the quality of sandwich bread during storage. Various variations of sandwich bread are available, such as whole wheat bread, grain bread, low-calorie bread, and sandwich bread with various fillings. As time goes by and the era has changed, many sandwich bread recipes have changed, the addition of various ingredients is done to create a sandwich bread texture that is in demand by people in the current generation.

Yeast and sugar contained in making sandwich bread function interrelated and affect the quality of the sandwich bread results (Thuy et al., 2023). With this commercial yeast, there are side effects that occur. In fact, the content in this commercial yeast is very foreign to be recognized by our digestive system, because of that a group of people even become allergic to this yeast itself. There is some evidence that natural yeast can help fight these diseases (Warnock & Richardson, 2018). White bread made using instant yeast generally has a higher glycemic

index (GI). This value is included in the high GI category, which means that this type of bread can cause a rapid increase in blood sugar after consumption. Research shows that the GI of white bread with natural yeast ranges from 50-65 (Fikria, 2023) while bread with instant yeast has 70-75 (Jenkins et al., 2018). This value is included in the medium GI category, which means that the increase in blood sugar after consuming this type of bread is slower and more stable compared to bread using instant yeast (Warnock & Richardson, 2018). The fermentation process plays a crucial role in the dough's elasticity and plasticity, allowing it to trap gas from fermentation. Gluten compounds in wheat also contribute to the bread's flavor and aroma (Thuy et al., 2023). The addition of fats can improve texture, extend shelf life, and give the bread a richer flavor. After fermentation, the dough is divided, shaped into an oval, and proofed before baking at 200°C.

Plants in Indonesia are also very diverse, the palm tree or better known as the lontar tree is one of them. The male flowers are tapped by cutting the ends and given a container to collect the water (Irawan, 2020). Palm sap comes from the palm plant, especially the part of the flower bunch stalk that is tapped for about ten hours. The male flower bunch that is tapped, on the other hand, is left to grow into palm fruit (Ismawati & Yuniastri, 2019). In Tuban Regency itself, there is a village where most of its resident's work as farmers or Siwalan climbers, namely Boto Village, Semanding. From this result, often several bottles that are not sold on that day are used as the basic ingredients for making other processed products, namely tuak. Pati wolo only lasts for 3 months, which means that if there are 9 months of production, the tuak continues to be abundant. To take advantage of the overflow that occurs, white bread that uses tuak as a substitute for yeast can be used as an alternative to other processed products besides making tuak and palm sugar.

This study focuses on sandwich bread using high-protein flour. In this experiment, the author will utilize palm sap called 'pati wolo' by local residents from a small district in East Java, namely Tuban (Irawan, 2020). Fermentation that occurs in palm sugar water is due to the change of sucrose into alcohol by microorganisms and gradually becomes more acidic (Irmayuni et al., 2018). *Saccharomyces cerevisiae* and *Acetobacter sp* are microorganisms that grow very quickly which allows fermentation to occur without adding anything (Khatimah, 2018). Therefore, in the development of this product, there will be a replacement of instant yeast with palm sugar water which has a specification of 3-4 hours old. One siwalan tree aged 10-20 years can produce 15 to 20 liters per day, this is divided into 6-12 liters in the morning tapping and also 4-8 liters in the afternoon tapping (Susilowati et al., 2017). This can happen on normal days outside the rainy season, if the rainy season comes, Siwalan farmers often do not get much yield from palm sugar water.

LITERATURE REVIEW

Instant Yeast

The leavening agent in bakery products produces gas to add volume to the product and also forms the desired structure in the final result. The three main contents in leavening agents or yeast are carbon dioxide, steam, and air. Fermentation that occurs when yeast is added to bakery products reacts with sugar and converts it to carbon dioxide and alcohol (Khetarpau et al., 2005). When this process occurs, the gas will be released and the alcohol will evaporate completely shortly after the baking process is complete (Gisslen, 2021).

Yeast can be thought of as a small enzyme machine that breaks down sugars into smaller, simpler molecules. However, yeast lacks amylase and cannot break down starch into sugars, so amylase is often an additive in the bread baking process. The distinctive aroma of bread made with yeast is produced by this acid molecule. Often a longer, slower fermentation will produce the desired aroma and flavor. This type of yeast comes in a block shape resembling clay and must be stored in a chiller. Dry yeast or dry active yeast is made by putting wet yeast into a dryer to remove 90% of the water content in it and kill a quarter of the yeast cells. Instant yeast is often sold with the label 'rapid rise', 'quick rise' (Table & Mushet, 2008).

Legen Water

The palm sap that will be used comes from Tuban Regency. Tuban Regency is bordered by the sea, limestone hills, and most of its areas have typical soil characteristics in the form of red soil and humus soil, this is in accordance with the characteristics of plants in Tuban Regency (Tuban Regency, 2018). This siwalan tree is included in the category of palms which are classified as sturdy and strong (Khatimah, 2018). The Siwalan tree itself can be utilized starting from the sap, seeds, stems, to the leaves. Leaves can be used as materials for manuscripts or crafts. The tapped male flowers will produce siwalan sap or can also be called legen water (Khatimah, 2018). Although it has the same basic ingredient, namely siwalan sap water, in making tuak, there are several tree barks that are added to preserve the fermented sap water so that it does not turn sour, the bark used is juwet tree bark, cashew tree bark (Kurniahu et al., 2021).

From a health perspective, tuak has been proven to be unhealthy when consumed over an extended period, as evidenced by research on kidney damage resulting from prolonged consumption. In this current study, nira siwalan (*Palmyra palm sap*) will be used. Before extensive fermentation occurs, legen is best consumed when

fresh. In practice, the tapping of legen is done at two times: morning and evening. The sugar content in legen tapped in the evening is higher compared to morning tapping. However, the alcohol content also increases over time. It is known that the difference in sugar content between morning and evening tapping is due to the photosynthesis process of the tree. Carbohydrates accumulate during the day, resulting in higher sugar content in legen tapped in the evening. From morning to midday, the photosynthesis process is quite intense, producing a relatively high sugar content (Imran et al., 2021).

The fermentation process can occur optimally if the pH of legen is at the optimum value of 4.3 - 4.7. This is because, within this range, the activity of enzymes involved in the fermentation process is at an optimal level. This pH also creates an environment that is sufficiently acidic to inhibit the growth of unwanted microorganisms while still allowing fermentation microorganisms to thrive (Borse et al., 2007; Mizana et al., 2016). If the pH of legen falls below 3, fermentation will proceed slowly, which would be detrimental to this study, as the author intends to optimize legen as a leavening agent. From research conducted by Hotijah et al., (2019) that legen will be at its optimum point when stored for up to 3 hours and when tapped in the evening.

Table 1: Legen Water Composition

Component	Amount
Total sugar (g/100cc)	10,93
Reduced sugar (g/100cc)	0,96
Protein (g/100cc)	0,35
Nitrogen (g/100cc)	0,056
pH (g/100cc)	6,7 – 6,9
Specific gravity	1,07
Minerals as ash (g/100cc)	0,54
Calcium (g/100cc)	11,8
Phosphorus (g/100cc)	0,14
Iron (g/100cc)	0,4
Vitamin C (mg/100cc)	13,25
VitaminB1 (IU)	3,9

Source: Khatimah, 2018

Legen water, also known as Air legen or siwalan sap, has various ingredients and compounds that can impact the production of fresh bread. It contains carbohydrates, mainly sucrose and fructose, which influence the flavor and texture of the bread while providing nutrients for yeast fermentation. Legen water is rich in minerals like potassium, magnesium, calcium, phosphorus, and iron, which activate yeast and contribute to a good bread structure. Additionally, it contains organic acids such as citric acid, malic acid, and succinic acid, which regulate the dough's pH, essential for yeast activity and gluten formation. Phenolic compounds like flavonoids and tannins in legen water possess antioxidant properties that prolong the shelf life of fresh bread (Balasundram et al., 2005). Enzymes such as amylase and invertase found in legen water aid in carbohydrate digestion and influence the texture and flavor of white bread. Furthermore, volatile compounds like alcohols and esters in legen water contribute to the aroma and flavor of fresh bread. Considering these various ingredients and compounds, the inclusion of legen water in bread making can impact several aspects of the final product (Lempang & Mangopang, 2012).

Hard Flour

Hard flour or often referred to as bread flour has a higher protein value compared to all-purpose flour. The use of this flour is more recommended in bread making. This is because when the dough with high protein flour is stirred, it will allow it to capture the carbon dioxide released by the yeast. Using low protein flour will result in flat loaves, faster stale, more crumbs, dense, and less chewy (Shapter, 2000; Myhrvold & Migoya, 2017). Gluten formation occurs when liquid is added to flour with gluten, which gives the bread its structure and shape. Higher protein also results in more browning bread (Beranbaum, 2014). The protein content in this flour ranges from 12% - 14% (Table & Mushet, 2008).

Sugar

In the bread making process, the role of sugar is very important, sugar provides food for yeast so that natural yeast can do its job, because when yeast is fed, they produce CO₂ which is trapped in the gluten network and causes bread to rise (Table & Mushet, 2008). The addition of sugar in bread making involves two chemical processes, namely reduction and maillard reaction. Both of these reactions occur when the bread dough is at a high temperature so that the sugar breaks down and reacts with other ingredients, giving it a full flavor and browned crust (Myhrvold & Migoya, 2017).

Salt

Salt plays an important role in the bread making process. Bread without salt will be bread without any flavor and the dough will be loose and also stickier. Salt not only enhances flavor, but also slows down the fermentation process. Without salt, the dough will ferment too quickly consuming all the sugars contained in it, resulting in a bread product that has a pale crust (Myhrvold & Migoya, 2017). A long, slow fermentation gives a better final flavor. Salt is hygroscopic, meaning it attracts and binds water, so it helps bread stay soft and fresh longer by retaining moisture (Table & Mushet, 2008). Too little salt will make the bread stale faster while too much salt will cause a harder crust (Shapter, 2000).

Butter

The flavor of baked goods depends on what type of fat is used and how it is mixed with other ingredients. As an important ingredient, butter affects several aspects in the process of making white bread. First, butter contributes to giving bread a rich and delicious flavor (Hui, 2006). The fat contained in butter enriches the flavor and enhances the overall deliciousness of the bread (Panesar, 2011). In addition, butter also plays a role in forming a soft and crumbly texture in white bread (Gisslen, 2017). During the kneading process, butter helps to create a smoother and more elastic gluten structure, resulting in soft and tender bread. Butter also contributes to extending the shelf life of white bread by slowing down the hardening or drying process (Cauvain & Young, 2008).

Egg

Eggs are one of the key ingredients in the bread-making process. Its presence provides a number of important benefits that affect the final quality of white bread. Firstly, eggs contribute to the formation of a compact and uniform bread structure. This is due to lecithin, which acts as an emulsifier, and ovalbumin, which contributes to structure formation (Hui et al., 2008). Lecithin helps to mix bread ingredients evenly, while ovalbumin helps to form a firm molecular network in the dough. This compact and uniform structure is important for producing a soft and fluffy bread texture. The addition of eggs in bread in addition to providing a yellowish color effect, eggs also interact with gluten proteins in terms of softening the crust along with adding volume to the crumb so that it becomes softer (Myhrvold & Migoya, 2017). In addition, eggs also contribute to the rich flavor of the bread because that is where the fat concentrates are (Figoni, 2010).

Milk Powder

Milk powder plays an important role in fresh bread making as it provides several benefits. Milk powder increases the nutritional value of bread by adding protein, vitamins, and minerals (Cauvain & Young, 2008). The protein in milk powder contributes to the formation of a good gluten structure (Tamime, 2009). Lactose in milk powder serves as a natural sweetener and helps produce an attractive bread crust color (Pylar & Gorton, 2008). Milk powder improves the softness of texture and extends the shelf life of bread by binding water (Zhou & Hui, 2014).

METHODOLOGY

This research focuses on the use of the experimental method, specifically in product development. The experimental method is a way for students to conduct in-depth studies and learn through experimentation (Creswell & Creswell, 2018). It involves investigating variables and understanding the relationship between them. In this case, the author conducted a pre-experiment comparing the use of legen water, instant yeast, and a yeast replacement with legen water. The author found that using 87.5% yeast replacement with legen water resulted in more optimal results compared to using 100% legen water. The objective of the experiment was to determine the impact of replacing the main ingredient with legen water on the final proofing time of the product, specifically when the product is 3-4 hours old. The hedonic test, or affective test, measures liking for a product based on likes or dislikes. The 9-point scale in table 2, developed at the U.S. Army Food and Container Institute, will be used to measure the result.

Table 2 : Panelist Rating Scale

Description	Very Strongly dislike	Strongly dislike	Dislike	Slightly dislike	Neutral	Slightly like	Like	Strongly like	Very Strongly Like
Score	1	2	3	4	5	6	7	8	9
Score after the formula	1 - 65	66 - 130	131 - 195	196 - 260	261 - 325	326 - 390	391 - 455	456 - 520	521 - 567

Adapted from: Lawless and Haymann 2010

Data analysis and measurement are crucial stages in a study, allowing researchers to answer problems. Sensory evaluation is a scientific method used to measure and interpret responses to products through our five senses. Data collection involves random marking of samples to avoid biased assessments. Sensory testing will be conducted to test public liking levels on sandwich bread with commercial yeast and legen water as a fermentation ingredient. The most suitable test is with lay panellists rather than expert panellists.

In this study, there will only be two samples given to untrained panellists. Market acceptance tests that aim to determine consumer preference for a sensory product require 50 to 100 panelists. Therefore, the number of panellists in this product development will use 63 untrained panellists. (Moskowitz, 1983). The data from 63 panellists will be compiled into a table. The conclusion that is the basis of the research discussion will be obtained from the summation of the overall score of the panellist data which is also called the total score. The calculation of the total score will use the total formula as follows:

$$\Sigma f(x) = (Fx1) + (Fx2) + (Fx3) + \dots + (Fx9)$$

Source: Nazir, 2003

Since the author will use 63 panellists, the range for making decisions will be based on the lowest score to the highest score. Based on this data, a range will be obtained to make decisions by referring to the division of the highest score with the number of scales that the author uses to get an interval of 63 scores like the table 2. The data will be grouped into 4 criteria, texture, taste, aroma, and color.

$$\Sigma f(x) \text{ Low score} = (F x 1) = 1 x 63 = 63$$

$$\Sigma f(x) \text{ High score} = (F x 9) = 9 x 63 = 567$$

Source: processed by the author, 2024

FINDINGS

The author has conducted an experiment which took place at the author's residence. This experiment has been conducted 3 times on April 14, 2024, May 17, 2024, May 19, 2024 which resulted in sandwich bread products using yeast and also sandwich bread products using legen water. Both products use the same technique and methodology, and the weight per loaf is also the same, only different in fermentation time. Table 3 present the results of the experiments.

Table 3 : Experiment Results

Description	Side of Sandwich Bread	Top of Sandwich Bread	The inside of Sandwich Bread
Sandwich Bread Using Yeast (Comparison)			
Sandwich Bread Using Legen Water (Experiment)			

Source: Author's Documentation, 2024.

The documentation obtained from the comparison product, namely Sandwich Bread using yeast and the experimental product sandwich bread using legen water, produces a documentation table as above. Because it uses the same pan, the shape of both is equally square and there is no noticeable difference in terms of

appearance. From the beginning to the end of the process of making sandwich bread, the author collects further observation data, the author classifies it into 4 parts, namely taste, aroma, color, and also texture. The following author's observations results in table 4 from sandwich bread products that use yeast and also sandwich bread products that use Legen water.

Table 4 : Observation Results

Aspect	Sandwich Bread Using Yeast (Comparison)	Sandwich Bread Using Legen Water (Experiment)
Colour	Evenly colored and brown	The color is uneven, the darkest part is on the top side of the sandwich bread
Taste	The milk powder and butter in it were the most prominent flavors.	The flavor of the legen water itself was quite pronounced especially at the end of the tasting. The bread was sweeter than the comparator.
Texture	Soft, tender and fine crumb with few evenly distributed pores, and slightly chewy when chewed.	Soft, less crumb, evenly distributed pores with a chewier texture.
Aroma	Dominated by the characteristic aroma of milk and toasted butter.	There is a slight aroma of milk and butter but there is a distinctive smell of fermented legen, slightly sour.

DISCUSSION

The author conducted the panellist test around the author's residence and regional government office of Tuban Regency. After the hedonic test was completed, the author processed the data from the panellist test results and outlined in a table for each aspect of the assessment. After conducting the experiment, the author decided to conduct a panellist test which was carried out on May 20-23, 2024, and the author distributed questionnaires to 63 untrained panellists to get the opportunity to try a comparison sandwich bread product with 100% yeast use (X8AM) and also an experiment using a formula of 87.5% yeast replacement to legen water (X7AL) (See Table 5). The purpose of this panellist test is to determine the level of liking of the panellists for the product that the author presents, or by hedonic test. The aspects that will be assessed by panellists are divided into 4 parts, namely texture, aroma, color, and also taste. In order to get objective results and without interference from the author's opinion, the author did not provide any information to the panellists in order to get pure and honest opinions from the panellists. Supporting this goal, the codes X8AM and X7AL were used by the author to disguise which product was the comparison and which was the experimental product.

Table 5 : Panelist Result

Score	Comparison Frequency (X8AM)				Experiment Frequency (X7AL)			
	Taste	Colour	Aroma	Texture	Taste	Colour	Aroma	Texture
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	1	0	1	2	1	0	0	0
4	4	1	3	2	1	0	4	2
5	8	12	7	9	7	7	6	8
6	2	2	6	8	3	2	6	9
7	19	16	17	19	16	16	17	12
8	18	20	17	14	23	21	17	17
9	11	12	12	9	12	17	13	15
Total Score	447	456	449	433	464	480	454	457

Based on the above results, the total score for the taste of the comparison product of 447 falls into the like category, while for the experimental product of 464 falls into the very like category. This shows that more panellists liked the sweeter taste with a sour after taste of the experimental sandwich bread product using legen water compared to the comparison product using mineral water and yeast. There is a difference in the total score of 17.

While the total score for the comparison product in the color aspect of 456 is in the very like category while for the experimental product of 480 is in the very like category. This shows that more panellists like the brownish color of the experimental sandwich bread product using legen water compared to the comparison product using mineral water and yeast. There is a difference in the total score of 24.

Meanwhile, the total score for the aroma of the comparison product of 449 is in the like category, while for the experimental product of 454 is also in the like category. This shows that more panellists liked the sour and sweet aroma of the experimental sandwich bread product using legen water compared to the comparison product using mineral water and yeast. Then for the total score of texture in the comparison product of 433 in the like category, while for the experimental product of 457 in the very like category. This shows that more panellists like the chewy texture and soft crumb of the experimental sandwich bread product that uses legen water compared to the comparison product that uses mineral water and yeast. There is a difference in the total score of 24.

CONCLUSION

From the results of the experiments carried out by the author, there are conclusions that can be drawn from the data obtained from the research on the use of legen water in making sandwich bread as a substitute for the role of yeast in making sandwich bread. The conclusions from the 4 aspects that the author assesses are as follows:

Assessment on the color aspect, it can be concluded that legen water can be used in making sandwich bread to replace most of the instant yeast. The experimental product that used 87.5% replacement of instant yeast in color had a very striking difference with the same baking time. The experimental product had uneven browning with the top much more browning than the other side. Whereas in the comparison product, the color tends to be even on all sides.

The assessment on the flavor aspect concluded that legen water can be used in making sandwich bread to replace most of the instant yeast. The comparison product that uses 87.5% instant yeast replacement in taste has a very striking difference. The comparison product has a flavor that is more dominated by the taste of milk and also butter which is typical of sandwich bread (Patel et al., 2020). Meanwhile, the experimental product has a sweeter taste compared to the comparison product and has a distinctive final taste of legen water.

Assessment on the texture aspect, it can be concluded that legen water can be used in making sandwich bread to replace most of the instant yeast. The comparison product, which used 87.5% instant yeast replacement, was texturally different from the experimental product. When cut, the experimental product produced fewer crumbs compared to the comparison product. There was quite a different chewy texture between the two, with panellists preferring the chewiness in the experimental product. The soft texture of the two did not have much difference.

Assessment on the aroma aspect, it can be concluded that legen water can be used in making sandwich bread to replace most of the instant yeast. The comparison product that used 87.5% instant yeast replacement had a difference in aroma, the experimental product had a faint sour aroma but was defeated by a more fragrant sweet aroma. Whereas in the comparison product the most striking aroma is the aroma of milk and also sweet which is quite faint.

RECOMMENDATIONS

Based on the results of the panellists and the research, there are several recommendations that the author recommends in making sandwich bread using legen water, to produce a color that is not too browning and dark, the author recommends reducing the baking time by 5-8 minutes so that the final result is not too dark and also browning on the top of the sandwich bread. The author suggests reducing the amount of sugar in sandwich bread recipes that use legen water, because the legen used by the author himself already has 12% sugar content.

Authors also recommends using legen water that is not more than 5 hours after tapping to get maximum results. In terms of texture, the author recommends trying other methods besides what the author did, such as making a starter first. This allows for better results as well as longer-lasting legen water. The experimental product had a faint sour smell. The author suggests not to ferment for more than 10 hours. Because this can make the sour aroma stronger than the sweet aroma that emanates.

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