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Effect of Drying Method on the Production of Dehydrated Sourdough Starter from Fermented Papaya (*Carica papaya L*)

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ABSTRACT
Yeast is a leavening agent used in bread-making that contains microorganisms of the *Saccharomyces cerevisiae* species. The use of yeast in bread-making is known for its practicality and ease, but yeast intolerance often occurs. As an alternative, natural yeast can be used to address this problem. Natural yeast has several benefits, such as enhancing flavor and aroma, prolonging the shelf life of bread, improving digestibility, maintaining bread softness for an extended period, and being free from additional chemical additives. However, natural yeast also has some disadvantages, such as a moist and brittle texture, which leads to a relatively shorter storage time. Therefore, this study aimed to investigate the impact of different drying techniques on natural yeast derived from fermented papaya fruit water. The drying techniques employed were air-drying for five days, sun drying for five days, and oven drying at 40°C for 48 hours. The best-dried yeast was obtained through the 5-day air-drying process, with a moisture content of 13.1%, nitrogen content of 2.07%, lactic acid bacteria colony count of 9.50×10^3 CFU/g, and an average preference rating of 3.92 for appearance, aroma, and color by the panelists. Furthermore, the dried yeast was successfully reactivated, with a volume expansion of 3 times from the initial height of 3 cm to 9 cm.

1. Introduction

Bread, typically made from flour, water, yeast, and other additives, is one of the staple foods people consume worldwide. The bread-making process involves fermentation aided by yeast, specifically microorganisms of the *Saccharomyces cerevisiae* species. In the production of bread, yeast functions to ferment carbohydrates, resulting in the production of CO_2 (carbon dioxide) and ethanol. The dough of bread or pastry expands due to the trapped CO_2, which occurs within the gluten present in the flour (Carullo et al., 2020; Srivastava et al., 2022). The population's high consumption of bread products has led to significant demand for yeast in Indonesia. Yeast can be classified into dry/instant yeast and compressed yeast. Dry/instant yeast was first created in Paris in 1853 to facilitate faster bread production in terms of development and preparation time (Fadiati, 2021).

Milk and its derivatives, such as butter, cream, and cheese, are commonly used in bread-making. The addition of these ingredients enhances the quality of bread by providing additional nutrients, improving color, and imparting distinct flavors and aromas (Sitepu, 2019). However, lactose, a component of milk and its derivatives, can cause health issues for lactose-intolerant individuals. Lactose intolerance is a clinical syndrome resulting from the inadequate hydrolysis of lactose due to lactase deficiency, characterized by symptoms such as bloating, abdominal pain, flatulence, vomiting, anal redness, and diarrhea. Low lactase production is often found in children over 5, reaching 3% in Northern Europe and nearly 80% in East Asia (Almon et al., 2013). The use of natural yeast in bread-making can help alleviate health issues for individuals with lactose intolerance. Natural yeast contains lactic acid bacteria that can break down lactose in milk into lactic acid (Kumalasari et al., 2013). Bread made with natural yeast (sourdough bread) differs from sweet bread typically made, as the addition of sourdough is believed to enhance the bread's taste, texture, shelf life, and nutritional content (Wolter et al., 2014).

Sourdough contains more live yeast cells that require careful monitoring of their development and metabolic needs. Consequently, the use of sourdough in bread-making has several drawbacks, including higher costs and difficulties in maintaining live microbial cultures (bacteria). Therefore, researchers are evaluating drying techniques to maintain high fermentation capacity and sourdough cell viability after drying. It allows the microorganisms in sourdough to become inactive during storage and reactivated during fermentation (Albagli et al., 2021). In this study, the drying procedure of sourdough will be conducted, referring to the research by Rahmawati et al. (2017), with several modifications, i.e., sun drying, air drying, and oven drying. Characterization of wet natural yeast will be conducted through pH testing, bacterial colony testing, and yeast activity testing. Additionally, characterization of the resulting dried natural yeast will be performed through water and nitrogen content as well as bacterial colony testing.

2. Methodology

2.1 Materials

Honeydew papaya (*Carica papaya* L.) was obtained from the local market in Pekanbaru, Indonesia, and used to prepare papaya juice. High-protein flour (Cakra Kembar, Indonesia), mineral water (Le Minerale, Indonesia), sugar (Gulaku), sterilized distilled water, NaCl (Merck, Germany), Nutrient Agar media (NA), a mixture of p.a. grade selenium compounds ($CuSO_4$, Na_2SO_4, selenium) (Merck, Germany), concentrated sulfuric acid (Merck, Germany), 1% H_3BO_3 (Merck, Germany), 40% NaOH (Merck, Germany), Conway indicator (methyl red, bromocresol green, 96% ethanol) (Merck, Germany), and 0.050 N H_2SO_4 solution (Merck, Germany) were also used.

2.2 Methods

This research was conducted in multiple stages. Firstly, the cleaned and peeled papaya was mixed with water in a ratio of 1:2, then mashed and heated over low heat for 5 minutes. The papaya juice was then mixed with 15% sugar of the total amount and fermented for six days at room temperature. pH measurements were taken daily during the fermentation process. The resulting fermented water was then inoculated with a starter culture five times to establish sourdough. The nourished natural yeast was then dried using the air-drying technique (5 days), sun drying (5 days), and oven drying (at 40°C) for 48 hours. Sun-drying involves exposing natural yeast to sunlight for 8 hours daily over five days (Rahmawati et al., 2017). The formed dried yeast was characterized through water content testing, nitrogen content testing, yeast activation testing, organoleptic testing, and bacterial colony testing.

3. Results and Discussions

3.1 Analysis of pH in Fermented Papaya Juice

The pH of fermented papaya juice was analyzed to assess the acidity level during the fermentation process. pH measurements were taken at different intervals to monitor acidity changes over time. A pH meter was calibrated using standard buffer solutions with known pH values to conduct the analysis. The fermented papaya juice samples were then prepared by collecting a representative portion of the juice at each designated for six days. pH represents the acid-base condition of the medium for a particular microorganism, which can affect its growth (cell division activity). pH that is too low (acidic) or too high (basic) can lead to cell death of the microorganisms. High levels of microbial death can impact the fermentation rate as the number of microorganisms decreases in their ability to break down glucose and produce ethanol (Taslim et al., 2017). The test results can be seen in **Fig. 1**.

Fig. 1 illustrates a decline in pH as the fermentation process progresses. The pH values obtained on the first to sixth days are 5.23, 4.75, 4.31, 3.82, 3.74, and 3.6, respectively. Previous studies have observed similar trends (Devita et al., 2019; Oshiro et al., 2020; Mutamima et al., 2023). The decrease in pH of the fermented papaya juice is attributed to the formation of lactic acid and alcohol during the fermentation of glucose, which serves as an energy and carbon source for bacterial growth.

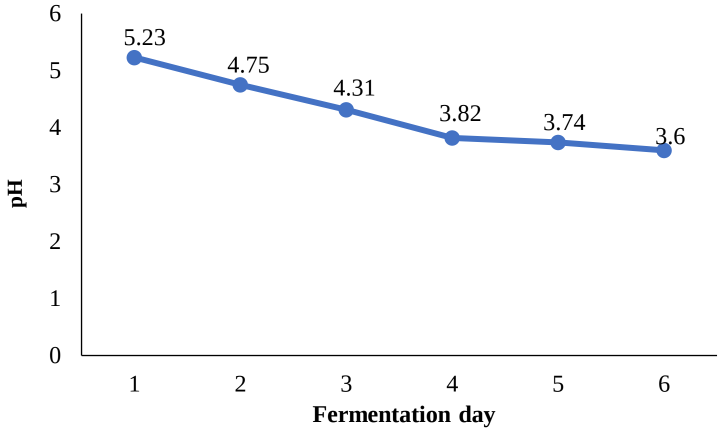

Fig. 1. Graph depicting the relationship between fermentation time and pH value

3.2 Effect of Drying Techniques on Yeast Moisture Content

Moisture content plays a pivotal role in determining the shelf life of stored products; the lower the moisture content, the longer the yeast's shelf life. Moisture content was determined by oven-drying at 105°C for 10 minutes until a constant value was achieved. The results obtained from this moisture content analysis are presented in **Table 1**.

Table 1. Moisture content value in dried yeast

Drying techniques	Moisture content (%)
Air-drying for five days	13.1
Sun drying for five days	11.4
Oven drying (at 40°C) for 48 h	9.9

Based on **Table 1**, the moisture content obtained from the various drying techniques is as follows: air-drying resulted in 13.1%, sun drying resulted in 11.4%, and oven drying (at 40˚C) resulted in 9.9%. In this study, the lowest moisture content was achieved in yeast dried using an oven (40˚C), which is consistent with the findings of Rahmawati et al. (2017), where dried yeast produced through oven drying (40˚C) had a moisture content value of 9.41%. The moisture content of yeast dried in an oven shows the lowest value, while that dried with air exposure exhibits the highest value. This tendency is likely attributed to yeast dried in an oven not being directly exposed to a heat source, relying solely on the force of the generated airflow. Water content within food substances significantly influences their resilience against microbial attacks, which microorganisms can exploit for their growth. To enhance the shelf life of a substance, a portion of its water content must be eliminated. The active dry yeast type typically contains a moisture content of 7.5-9% (Mudjajanto et al., 2009).

3.3 Effect of Drying Techniques on Yeast Activation

Yeast thrives well under aerobic conditions (presence of oxygen), but anaerobic conditions (absence of oxygen) are preferred in yeast production processes, as aerobic growth might lead to contamination. Maintaining a consistent temperature is advisable for yeast storage, as fluctuating temperatures can stress microbes. A sufficient supply of sugar is also essential during the fermentation process. Insufficient sugar may lead to the growth of harmful bacteria and weaken yeast (Ko, 2012). In this study, dried yeast was activated by introducing a substrate to the dried yeast. Before adding the substrate, dried yeast was activated by adding warm water and dissolving it until it was suspended. Activation data is presented in **Fig. 2**.

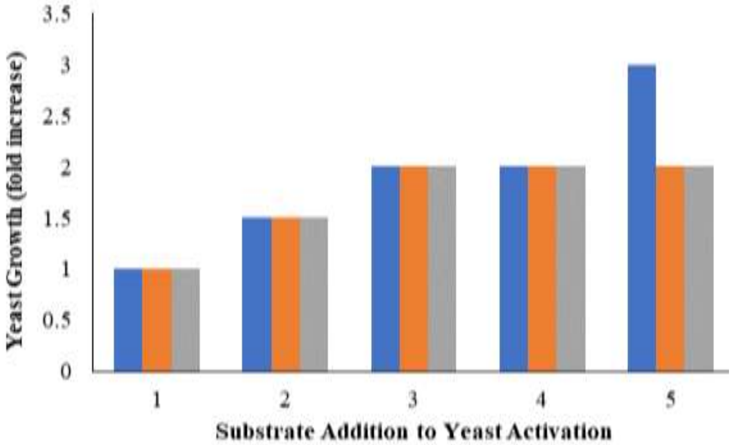

Fig. 2. The effect of drying techniques on yeast activation; the blue graph represents air drying for five days, the orange graph represents sun drying for five days, and the grey graph represents oven drying for 48 h.

Based on **Fig. 2**, the yeast that has been activated and given the first substrate does not show an increase in volume but demonstrates signs of yeast activity, such as the emergence of air bubbles. Subsequently, with the second substrate addition, the yeast undergoes a volume increase of up to 1.5 times its initial volume. With the third substrate addition, the yeast's volume increases twice. Upon the fourth substrate addition, the yeast experiences a doubling of its initial height, and with the fifth substrate addition, the yeast dried using the air-drying technique expands by three times its initial volume, whereas with sun drying and oven (40˚C) drying techniques, the expansion is limited to 2 times the initial height. It could be attributed to a higher bacterial population in the yeast subjected to air-drying, leading to a faster development process. The yeast activation process, until full expansion, requires 12 h.

3.4 Effect of Drying Techniques on Nitrogen Content

Protein content can be determined using the Kjeldahl method, as it indirectly analyzes the crude protein content present in food substances. The results obtained from protein content determination using the Kjeldahl method are presented in **Table 2**. **Table 2** reveals that the nitrogen content obtained from various drying techniques is 2.07% for air-drying, 1.96% for sun drying, and 1.98% for oven-drying (at 40˚C). According to the SNI 01-2982-1992 standard for dry yeast, the nitrogen content should be in the range of 6.0-7.5%. In this study, the produced yeast demonstrates a distinct nitrogen content from the SNI 01-2982-1992 standard, which could be attributed to the utilization of different microorganisms compared to commercial yeast. Commercial yeast typically contains *Saccharomyces cerevisiae*, while natural yeast contains lactic acid bacteria. The higher nitrogen content in air-dried yeast compared to sun drying and oven (40˚C) drying could be due to a larger bacterial population present in the yeast subjected to air-drying, leading to elevated nitrogen content in the yeast.

Table 2. Nitrogen content in dried yeast

Drying techniques	Nitrogen content (%)
Air-drying for five days	2.07
Sun drying for five days	1.98
Oven drying (at 40°C) for 48 h	1.96

3.5 Sensory Evaluation of Dried Yeast

Following the production of yeast, the dried yeast samples were provided to 25 untrained panelists for sensory evaluation. The assessment of organoleptic quality encompassed parameters such as appearance, aroma, and color. Subsequent to data analysis, the test outcomes are presented in **Fig. 3**.

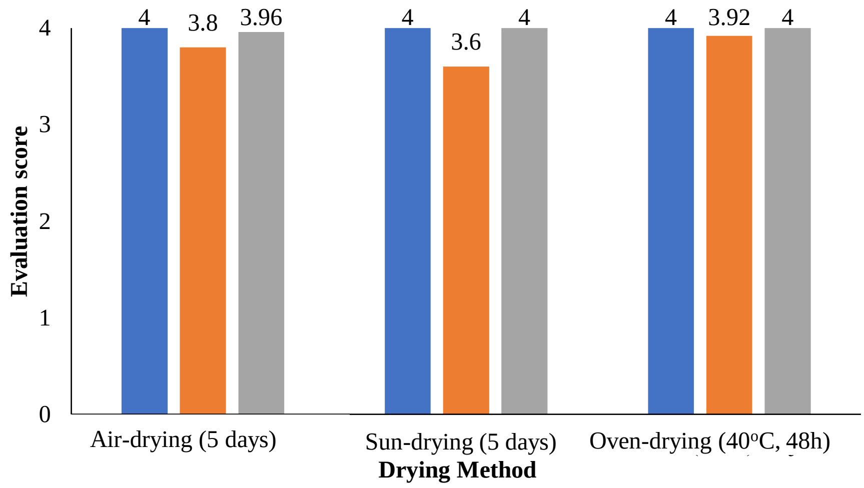

Fig. 3. Sensory evaluation of dried yeast from appearance in blue, aroma in orange, and color in grey

Fig. 3 shows that the highest appearance, aroma, and color scores are attributed to the drying technique using an oven (40˚C) for 48 h. According to the SNI 01-2982-1992 standard quality requirements for dry yeast, the stipulated standards include an appropriate appearance resembling powder/grains, a white to pale yellow color, and a typical yeast-like aroma. The test results reveal that the outcomes obtained from all three drying techniques align with the standard quality criteria for dry yeast.

3.6 Bacterial Colony Test on Dried Yeast

Lactic acid bacteria (LAB) play a pivotal role in the fermentation process within this study. The most significant attribute of LAB is its capacity to ferment sugar into lactic acid. Fermentation occurs due to the presence of fermentation-causing microorganisms on suitable organic substrates. The results of the bacterial colony test on dried yeast can be observed in **Table 3**.

Table 3. Bacterial colony count in dried yeast

Drying techniques	TPC (CFU/g)
Air-drying for five days	9.50×10^3
Sun drying for five days	7.00×10^3
Oven drying (at 40°C) for 48 h	5.20×10^3

From **Table 3**, it is evident that each drying technique yields a distinct total count of LAB. The yeast produced through the air-drying technique demonstrates the highest LAB count, 9.50×10^3 CFU/g. Subsequently, the total LAB count for sun drying is 7.00×10^3 CFU/g, and for oven drying (at 40˚C), it is 5.20×10^3 CFU/g. The higher total LAB count in air-drying is due to the drying process not directly contacting high heat/temperature, thus preserving more viable bacteria. Conversely, yeast dried under sunlight and in the oven (40˚C) experiences more bacterial death or damage due to direct heat exposure, resulting in a lower total LAB count for these drying techniques than air drying.

4. Conclusion

In conclusion, this study successfully demonstrated the production of dried yeast from papaya fruit fermentation water by employing various drying techniques. The air-drying technique emerged as the most promising approach among the tested methods. The optimal dried yeast achieved through air drying exhibited favorable characteristics, including a moisture content of 13.1%, nitrogen content of 2.07%, and a substantial count of lactic acid bacteria colonies at 9.50×10^3 CFU/g. Additionally, the sensory evaluation performed by panelists indicated a notable preference, with an average rating of 3.92, encompassing attributes like appearance, aroma, and color. Furthermore, the reactivation of the dried yeast was successfully achieved, demonstrating a threefold volume increase from its initial height of 3 cm to 9 cm. This research highlights the critical role of drying techniques in shaping the characteristics of dried yeast, with the air-drying method proving to be the most effective in preserving microbial content and sensory attributes. These findings contribute to optimizing dried yeast production processes, offering potential benefits for industries relying on yeast-based products. Further investigations into the applications and potential enhancements of dried yeast derived from papaya fruit fermentation are warranted to expand its utility and contribute to the broader food science and technology realm.

References

Albagli, G., Schwartz, I.D.M., Amaral, P.F.F., Ferreira, T.F., Finotelli, P.V. (2021) How dried sourdough starter can enable and spread the use of sourdough bread. *Food Science and Technology, 149*, 111888. https://doi.org/10.1016/j.lwt.2021.111888.

Almon, R., Sjöström, M., Nilsson, T.K. (2013). Lactase Non-Persistence as A Determinant of Milk Avoidance and Calcium Intake in Children and Adolescents. *Journal of Nutritional Science*, *2*, 1-5. https://doi.org/10.1017/jns.2013.11.

Carullo, G., Scarpelli, F., Belsito, E., Caputo, P., Rossi, C.O., Mincione, A., Leggio, A., Crispini, A., Restuccia, D., Spizzirri, U., Aiello, F. (2020) Formulation of New Baking (+)-Catechin Based Leavening Agents: Effects on Rheology, Sensory and Antioxidant Features during Muffin Preparation. *Foods, 9*(11), 1569. https://doi.org/10.3390/foods9111569.

Devita, M., Rizqiati, H., Pramono, Y.B. (2019). Pengaruh Lama Fermentasi Terhadap Kadar Alkohol, Lemak, Nilai pH, Dan Total Bal Kefir Prima Susu Kambing. *Jurnal Teknologi Pangan, 3*(2), 204-208.

Fadiati, A. (2021). Daya Terima Konsumen Pada Roti Soft Roll (Studi Tentang Pengaruh Penggunaan Ragi Alami Sourdough Berbasis Umbi-Umbian). *Jurnal Teknologi Busana dan Boga*, *9*(1), 61-69. https://doi.org/10.15294/teknobuga.v9i1.26299.

Ko, S. (2012). *Jayeon Bread A Step-by-Step Guide to Making No-Knead Bread with Natural Starters*: Marshall Cavendish Cuisine.

Kumalasari, K.E.D., Legowo, A.M., Al-Baarri, A.N. (2013). Total Bakteri Asam Laktat, Kadar Laktosa, pH, Keasaman, Kesukaan Drink Yogurt dengan Penambahan Ekstrak Buah Kelengkeng. *Jurnal Aplikasi Teknologi Pangan, 2*(4), 165-168.

Mudjajanto, Setyo, E., Yulianti, L.E. (2009). *Membuat Aneka Roti*. Jakarta: Penebar Swadaya.

Mutamima, A., Fadli, A., Purnama, I., Azis, Y., Izzuddin, M.S. (2023). Exploring the potential of fermented papaya as a functional ingredient for sourdough bread: a study on fermentation time and quality of sourdough donuts. *Jurnal Ilmiah Pertanian, 20*(1), 51-60. https://doi.org/10.31849/jip.v20i1.13064.

Oshiro, M., Tanaka, M., Zendo, T., Nakayama, J. (2020). Impact of pH on succession of sourdough lactic acid bacteria communities and their fermentation properties. *Bioscience of Microbiota, Food and Health, 39*(3), 152-159. https://doi.org/10.12938/bmfh.2019-038.

Rahmawati, Maulani, R.R., Saputra, D. (2017) Karakteristik Ragi Kapang Khamir Indigenus Untuk Pembuatan Tepung Jagung Putih Lokal Fermentasi. *Prosiding Seminar Nasional PATPI* Bandar Lampung, 1178-1185.

Sitepu, K.M. (2019). *Penentuan Knsentrasi Ragi Pada Pembuatan Roti* Makassar: Program Studi Ilmu dan Teknologi Pangan Fakultas Pertanian Universitas Hasanuddin.

Srivastava, S., Kollemparembil, A.M., Zettel, V., Claßen, T., Mobarak, M., Gatternig, B., Delgado, A., Jekle, M., Hitzmann, B. (2022). An Innovative Approach in the Baking of Bread with CO_2 Gas Hydrates as Leavening Agents. *Foods*, *11*(22), 3570. https://doi.org/10.3390/foods11223570.

Taslim, M., Mailoa, M., Rijal, M. (2017). Pengaruh pH, dan lama fermentasi terhadap produksi ethanol dari Sargassum crassifolium. *BIOSEL (Biology Science and Education): Jurnal Penelitian Science dan Pendidikan, 6*(1), 13-25. http://dx.doi.org/10.33477/bs.v6i1.129.

Wolter, A., Hager, A.S., Zannini, E., Czerny, M., Arendt, E.K. (2014). Impact of Sourdough Fermented with Lactobacillus Plantarum FST 1.7 on Baking and Sensory Properties of Gluten-Free Breads. *Eur Food Res Technol*, *239*, 1-12. https://doi.org/10.1007/s00217-014-2184-1.