Physicochemical properties of sourdough bread made from local variety sweet potato and pineapple juice

Zaidiyah¹, Y M Lubis*, C A R G Putri¹, S Rohaya¹

¹Department of Agricultural Product Technology, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam Campus, Banda Aceh 23111, Indonesia

*Corresponding author’s e-mail address: yantimeldasari@unsyiah.ac.id

Abstract. A study was done to evaluate the characteristic of sweet potato sourdough bread made by pineapple juice. The bread was formulated using different variation of ratio of pineapple juice to starter as follows; 4:1, 3:2, and 2:3 and sweet potatoes differ in their flesh colour. Starter development was also daily observed for 10 days. The proximate composition of bread analysed were 5.60% protein, 1.63% crude fat, 44.19% moisture and 1.51% ash. The total available carbohydrate was 45.91%. The breads pH and crude fibre were 3.73 and 1.15%. Bread physical characteristic were also conducted in order to ensure the bread quality such porosity and loaf volume bread. The sourdough bread prepared by liquid starter from pineapple juice and white sweet potato with a ratio of 4:1 met the best performance.

1. Introduction

Sourdough is a combination of flour (from wheat, rye, rice, etc.) and water, which is fermented by the activity of lactic acid bacteria and yeasts. These microorganisms commonly come from flour, dough ingredients or the environment. The fermentation process for sourdough is aim to highlight the superior characteristics of bread in the field of acid production, aroma and also the development of dough by slowing the staling process and protecting bread from fungi and spoilage bacteria [1]. Baking sourdough bread begins with sourdough starter (refreshment), or commonly called the source of sourdough bread. According to [2] the natural sourdough starter contains Lactobacillus, lactic acid bacteria that develop when flour and water are mixed together which then go through a fermentation process. Lactic acid along with acetic acid will destroy gluten, and make gluten easy to digest. The presence of Lactobacillus in the sourdough bread starter influences the taste of bread become sour. One of the natural ingredients that can be used in sourdough starter is pineapple juice. Pineapple juice has a very acidic pH value when compared to other fruit juices. In preparation of sourdough starter, pineapple juice help in decreasing pH. Low pH conditions can prevent the environment of Leuconostoc bacteria that can inhibit the growth of other lactic acid bacteria found in the starter [3].

Furthermore bread production by adding sweet potato paste is one of efforts to minimize imported wheat flour in Indonesia. Sweet potato can substitute wheat flour. Its production in Indonesia in 2018 reaches 1,914,244 tons [4]. [5] state that sweet potatoes contain carbohydrates and calories equivalent to flour. Sweet potatoes are easily produced in various fields in Indonesia with productivity values ranging between 20-40 tons / hectare of fresh tubers and also the price is low and easily obtained in the local market. The taste, texture and colour of sweet potatoes are also diverse. In this study the sourdough bread was substituted with sweet potato paste which are differ in their flesh color. Additionally they contain different chemical compounds such as sucrose, reducing sugar and dry
matter [6]. According to [7], sweet potato paste is made by steaming fresh sweet potatoes for ± 25 minutes, then ground to produce a soft texture.

Research regarding sourdough with addition of sweet potato paste still insignificant and need to investigate to find more information. The purpose of this study is to maximize the use of sweet potatoes differ in their flesh colour as local food products for making sourdough bread, produce food products with good nutritional value and diversify fermented baked goods.

2. Materials and Methods

2.1. Material

Materials used in this research were white, yellow and purple sweet potato, pineapple, wheat flour, margarine, sugar, and salt. The chemical used for analysis were aquadest, HCl, NaOH, H₂SO₄, Kjeldahl tablet, hexane solvent, and boric acid. The equipment used in making the sourdough were incubators. The equipment used for proximate analysis are filter paper, pH meters, and desiccator.

2.2. Pineapple Juice

Pineapples were peeled and cleaned. It is cut into fourths vertically. Moreover, the centre core of the pineapple was cut away in a vertical slice, and the core was discarded. Then pineapple slices was cut into chunks. Added water with ratio 1:2 (water: pineapple). The pineapple juice was strained and heated for 10 minutes.

2.3. Sourdough Starter [8]

Wheat flour, pineapple juice and water were mixed into dough until thoroughly-combined in a container and cover with plastic wrap. The dough was kept in incubator at a temperature of 22°C for 24 hours in order starter to become active and start bubbling. Afterward, half of the starter was discarded and water was added into starter. The dough should be stirred. Then 50 g of wheat flour and 50 g of pineapple juice and water were added, and stirred it again until it well-combined. The ratio of pineapple juice and water (50g) used in this research are 4:1, 3:2 and 2:3. This process was regularly repeated every 24 hours until 10th days of fermentation.

2.4. Sourdough Bread [8]

Sourdough breads were made from starter which were formulated wheat flour using three different ratio of pineapple juice and water (4:1, 3:2, and 2:3) and three different types of sweet potato differ in their flesh colour (yellow, purple, and white). Wheat flour, water, and starter were 150 g, 10 g and 60 g respectively mixed in plastic container, then 100g of sweet potato paste, 4g of salt, 10g of sugar and 10g of margarine were added to the mixture. The dough was kneaded until it well-kneaded and left for 1 hour. The kneading process was carried out in triplicate until the dough becomes elastic and does not easily tear. The fully kneaded dough was put in a plastic container and kept in the refrigerator for 14 hours. Finally, the dough was formed into breads, transferred to the baking tray and baked at 200°C for 50 minutes.

2.5. Starter Development [9]

Starter development level was examined in accordance to Hariyanto [9] in order to find out the activity and stability of starter. It can be measured by level in the container. The following equation is to calculate the starter volume in percentage:

\[
\text{Development percentage} = \frac{\text{final volume} - \text{initial volume}}{\text{initial volume}} \times 100\% \quad (1)
\]
2.6. Proximate Analysis [10]
The standard procedure of AOAC [10] has been applied for proximate analysis including moisture, crude protein, crude fat, and crude fibre and ash contents of the formulated bread. Total carbohydrates have been calculated from the sum of moisture, crude protein, crude fat, ash and crude fibre, and lastly subtracting it from 100 [10].

2.7. Porosity
Porosity test of formulated bread was referred to Surono et al. [12] by dividing the bread into three different parts (upper, middle, and lower part). Mica paper is cut equally to the bread. On the paper, a box with 1x1 cm was made, with 4 pieces of each paper. Then the bread pores which has been seen in each box would be counted and averaged. This process was repeated for each part of the bread then the average pore of each part was summed up and averaged again to determine the porosity value of the bread.

2.8. Data Analysis
Data were analysed using Analyses of variance (ANOVA). Significant differences were tested using the Duncan Multiple Range test. Three replications were used for chemical and physical measurements

3. Results and Discussion
3.1. Starter Expansion
Sourdough is a combination of wheat and/or rye flour and water, possibly with added salt, fermented by spontaneous (from flour and environment) lactic acid bacteria and yeasts which determine its acidifying and leavening capability. These activities are obtained and optimized through following refreshments (or re-buildings, replenishments, back-slopping). The liquid sourdough deals with the method by which a dough made of flour, water and possibly other ingredients ferments spontaneously for a certain time (possibly at a defined temperature) and it is subsequently added as an inoculum to start the fermentation of a new mixture of flour and water (and likely other ingredients) [13]. In this study, the refreshments consists of wheat flour, pineapple juice, and water with three different refreshments ratios (pineapple juice to water 4:1, 3:2, and 2:3) for 10 days in order to maintain the metabolic activity of the microbial communities at all times. According to the research, bubbling has been found at the beginning of fermentation days. Dormant cells of bacteria and fungi float through the air and live in flour. When they exist on a suitable material, they begin to reproduce. When yeast or bacteria have access to oxygen, aerobic fermentation produces carbon dioxide gas. Therefore, the bubbles formation within pineapple juice-wheat flour starter indicated the presence of wild yeast and lactic acid bacteria (LAB) [3]. Moreover, after 48 hours (2 days) the rise of starter was significantly increased and keeps slightly stable (Figure 1). It showed that ratio 4:1 (pineapple juice to water) has the highest development compared to other ratios including control.

Starter development of different ratios demonstrated different trend due to the quantity of refreshment material used. Refreshment ratio with 4:1 has highest pineapple juice contained more substrate to serve wild yeast and lactic acid bacteria. Juarez-Garcia et al. [15] informed that carbohydrates constitute the main element of fruits such as starch and non-starch polysaccharides that metabolize by bacteria and produce maltose. Maltose can be metabolised by yeast and produced carbon dioxide gas and ethanol, leavening the dough. Therefore ratio with higher of pineapple juice demonstrated highest than others. The trend is similar with other ratios. Higher refreshment of ratios are related with greater microbial stability in the sourdough and keeps acidity of the refreshed dough relatively low by amount of pineapple juice in order to prevent undesirable microorganism lactobacilli and favour acid-tolerant yeasts. Moreover the stability of starter development are also influenced by type of flour and temperature/time of fermentation [14].
3.2. pH value and proximate analysis of formulated bread

pH value of formulated sourdough bread range from 3.69 - 3.82. This result gives the similar information with Corsetti [13] that has pH around 3.8 - 4.6. Low pH value is due to the production of lactic and acetic acid by lactic acid bacteria linked with yeast during sourdough and refreshment preparation [16]. Sourdough bacteria ferment carbohydrate, fat and protein and produce acid, primarily lactic acid in sourdough environment [3]. Therefore sourdough bread taste sour and has low pH. As well acidity levels of below pH 4.0 inhibit lactobacilli and favour acid-tolerant yeasts.

Table 1. Proximate analysis of formulated sourdough bread

| Treatments | Moisture content (%) | Ash (%) | Crude protein (%) | Fat (%) | Carbohydrate (%) |
|------------|----------------------|---------|-------------------|---------|------------------|
| S1U1       | 43.88                | 1.75    | 6.54              | 1.54    | 46.29            |
| S1U2       | 40.70                | 1.57    | 6.04              | 2.79    | 48.91            |
| S1U3       | 44.20                | 1.79    | 5.60              | 1.64    | 46.78            |
| S2U1       | 40.67                | 2.35    | 7.61              | 2.55    | 46.82            |
| S2U2       | 43.41                | 1.71    | 6.82              | 1.98    | 46.08            |
| S2U3       | 41.05                | 1.81    | 6.90              | 1.32    | 48.92            |
| S3U1       | 34.76                | 1.79    | 4.63              | 1.23    | 57.59            |
| S3U2       | 35.92                | 1.79    | 6.04              | 0.71    | 55.54            |
| S3U3       | 37.82                | 1.95    | 6.58              | 1.87    | 51.78            |

Note S1 = starter ratio 4:1, S2 = starter ratio 3:2, S3 = starter ratio 2:3, U1 = sweet potato with yellow flesh colour, U2 = sweet potato with purple flesh colour, U3 = sweet potato with white flesh colour.

The chemical analysis revealed that the moisture content of formulated sourdough was in the range of 34.76 - 44.20%. This results were higher than the previous study done by Muhammad [17] which had the moisture content ranging from 19 - 30%. However, protein, and fat compound were lower compared to the previous study (10 -12%) which used plantain flour as sourdough starter constituent.
The protein content obtained in this study was only 6-8%. Nevertheless, sweet potato flesh colour and ratio of pineapple juice to water was not significant to proximate parameter ($p > 0.05$). The study investigated that sourdough with pineapple and flesh colour of sweet potato have no effect on formulated sourdough bread.

### 3.3. Crude Fibre, Bread Loaf, and Porosity

Crude fibre content of formulated sourdough bread was found much lower in the range of 0.4 – 2.4% compared than former research [17]. This research was observed bread with refreshment ratio of 2:3 showed highest fibre content which is different significant compared the ratio of 3:2 and 4:1 (figure 2). By reducing pineapple juice to water in refreshment ratio will effect metabolic process during leavening or fermentation. Amount of microorganism (bacteria and yeast) was produced specific enzyme that breakdown macromolecule, with low colony of microorganism was resulting higher crude fibre content. Moreover, a minor degradation of crude fibre content by sourdough LAB may be credited to a lower release of fermentable sugars by enzymes [18]. In general crude fibre content declines during dough mixing and baking process due to thermal condition.

Moisture content could influence solubility of polysaccharide in bread matrix. Therefore, this solubility indirectly affects the fibre content. Moreover in this ratio give more bacteria/yeast to degrade substrate in sourdough. This phenomenon applied also in bread loaf. By decreasing pineapple juice, volume will also reduce bread volume. Starter ratio 4:1 has the highest bread volume which is not different compare starter ratio 3:2 in yellow sweet potato. However purple and white sweet potato performed the same trend in all variant of ratios. Pineapple juice considered to influence bread volume due to its acidity, promoted bacteria and yeast produce carbon dioxide and ethanol. Nevertheless the study estimates the ratio is not acid enough in order to influence gluten and gliadin which are responsible for bread volume.

The research was found that bread loaf of formulated sourdough bread was influenced by refreshment ratio and sweet potato type. Figure 3 shown that bread with ratio 4:1 with yellow sweet potato flesh colour has the highest bread loaf even though there was no different with 3:2 refreshment ratio. The similar trend performed also in two others sweet potato but with lower bread volume. Bread with ratio of refreshment 4:1 along with starter volume have similar justification. Formulated sourdough bread with 4:1 ratio has the highest starter volume indicated has more microorganism (yeast and bacteria). The more microorganisms the more gas is formed. Yeast used in sourdough produces gas (carbon dioxide) which leavens the dough and bacteria produce lactic acid, which contributes flavor in the form of sourness. The lactic acid bacteria metabolize sugars that the yeast cannot, while the yeast metabolizes the by-products of lactic acid fermentation.

In the porosity test analysis in accordance to bread volume, all formulations of sourdough breads contained various sizes of isolated cells located in the upper side of crumb, closed to its crust. This happened when the carbon dioxide gas produced by natural leavening agent (sourdough starter), trying to escape the crumb but failed during the baking process. Observing from external crumb development, although all breads showed different final shapes, but their cell sizes are considered about the same, where each bread contain small and large cells arrangement, distributed in various unique ways. This happened due to availability of leavening agent (yeast) fermentation in the dough, producing $CO_2$, thus contributes to irregular sizes of crumb cell structure. Furthermore the rise time of most sourdough starters is longer than that of breads made with baker's yeasts.
Figure 2. Crude fibre of formulated bread sourdough

Figure 3. Bread loaf of formulated sourdough
4. Conclusions
This study considered starter ratio 4:1 give the best performance and yellow sweet potato flesh colour. As a conclusion, besides giving an extra added value for our local sweet potato and pineapple, this study also succeeded to prove that sweet potato and pineapple is applicable to be used as material for sourdough bread. Research need to continue regarding microbiology aspect and customer preference.

Acknowledgments
The authors are grateful to University Syiah Kuala for funding this research by PNBP in year of 2019 research programme.

References
[1] Rositsa D, Svetla, Zapryana D, Ljubka, Mariya Y, Dilyana N, 2015 Biotechnology & Biotechnological Equipment
[2] Hadjiandreou E 2016 How to Make Sourdough (United Kingdom: Ryland, Peters and Small Ltd)
[3] Rayner L 2009 Wild Bread: Hand-Baked Sourdough Artisan Breads in Your Own Kitchen. (United States: Lifeweaver LLC)
[4] Statistics Bureau of Indonesia 2018 Sweet Potato productivity in province Jakarta.
[5] Zuraida N dan Y Supriyati 2001 Usaha Tani Ubi Jalar Sebagai Bahan Pangan Alternatif dan Diversifikasi Sumber Karbohidrat Buletin Agrobio 4 13-23
[6] Zaidiyah 2014 Sucrose, Reducing Sugars, and Carotenoid Content of Aceh Besar Sweet Potato Cultivars (Ipomoea batatas L) J. TIP Indonesia. 613-16
[7] Steed L E and Truong V 2008 *J. Food Sci.* 73 S215-S221
[8] Greenway L T 2012 *Discovering Sourdough Part I Beginning Sourdough: Professional Sourdough Baked At Home* Northwest Sourdough
[9] Hariyanto A S 2015 *Formulasi roti ubi jalar ungu menggunakan sari buah nanas sebagai starter sourdough* Skripsi Katolik Soegijapranata University Semarang
[10] AOAC 1995 *Official Methods of Analysis* (Washington D. C.: The Association of Analytical Chemists)
[11] Surono D I, E J N Nurali, and J S C Moningka 2017 *Sourdough: A Tool for The Improved Flavour, Texture and Shelflife of Wheat Bread*
[12] Corsetti A 2013 *Handbook on Sourdough Biotechnology* (New York: Springer) pp 85–102
[13] Minervini F, De Angelis M, Di Cagno R, Pinto D, Siragusa S, Rizzello CG, Gobbetti M 2010 *Food Microbiol* 27 897–908
[14] Juarez-Garcia E, Agama-Acevedo E, Sayago-Ayerdi S G, Rodriguez-Ambriz S L and Bello-Perez L A 2006 *Plant Foods for Human Nutrition* 61 131-137
[15] Wehrle K and Arendt E K 1998 *Cereal Chemistry* 75 882–886
[16] T Mohammad, C Z Hassan, C W Zanariah 2011 6th Int. Congress Flour-Bread 8th Croatian Congress of Cereal Technologist 2011
[17] Danielle T S, Raffaela D S, Giovanni D and Andrea G 2017 *J. Food Sci Tech* 83 26-32