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Properties of Instant Sourdough from Papaya (*Carica papaya* L.) Natural Starter and Its Effect on Bread Characteristics

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Abstract: *Sourdough is made from water and wheat flour, fermented by lactic acid bacteria and yeast. Papaya can serve as a natural starter for producing sourdough. This study aims to assess the impact of drying on pH levels, total titratable acidity (% TTA), the viability of lactic acid bacteria (LAB), yeast viability, specific volume, and the texture profile of gluten and gluten-free bread. Three types of starters were used: P (fermented water from papaya and flour), G (fermented water from papaya, sugar, and flour), and W (mineral water and flour) to make type I sourdough (before drying). Type III sourdough (dried) was obtained using spray drying (S), cabinet drying (C), and freeze-drying (F). The pH, %TTA, LAB, and yeast viability were measured, while the specific volume and texture profiles of the breads were evaluated. Spray drying significantly affected the pH of the A sample and LAB viability in the W and G samples. Cabinet drying significantly affected the %TTA and yeast viability in the G sample. Freeze-drying significantly affected the LAB and yeast viability in the W and G samples, as well as yeast viability and %TTA in the P sample. Instant sourdough can be produced using spray, cabinet, or freeze drying and is suitable for making both gluten-containing and gluten-free bread. Variations in starter type and drying methods influence the bread's physical characteristics, including specific volume and texture profile. The drying methods significantly affected hardness, gumminess, chewiness, cohesiveness, springiness index, and resilience in both gluten-containing and gluten-free bread samples.*
Keywords: *sourdough; lactic acid bacteria; yeast; bread; specific volume.*

Type of the Paper: Regular Article.

1. Introduction

Papaya is one of the fruit varieties in Indonesia. Its skin ranges from green to yellow, and it has an oval shape. The flesh is smooth, delicious, and reddish-brown [1]. According to Chukwuka et al. [2], papaya serves as a suitable substrate for fermentation due to its high carbohydrate content. In addition, papaya contains organic acids, including citric acid, fumarate, tartaric acid, succinate, and malonate, resulting in pH range from 4.5 to 5.9 [3]. Due to its relatively low pH, incorporating papaya into the fermentation process is expected to provide a rich carbohydrate source, promoting the growth of lactic acid bacteria and yeast while accelerating the reduction of the product's pH [4].

Sourdough is created by fermenting a mixture of water and wheat flour with lactic acid bacteria (LAB) and yeast. Sourdough fermentation is often heterofermentative but can also be

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homofermentative, sometimes leading to the production of acetic acid bacteria [5]. According to Gänzle [6], lactic acid bacteria generate various metabolites, including organic acids, enzymes, and exopolysaccharides, which influence bread's sensory qualities, shelf life, nutritional value, and scent [7]. In addition to water, other ingredients such as fruit, honey, yogurt, or other items serve as inoculum or substrate during fermentation [8]. Fruits, in particular, can enhance the fermentation process by adding more nutrients to the microbiota. Compared to sourdough without fruit, fruit-fermented water can produce bread with a higher specific volume and promote different forms of LAB strains, as seen in pear and orange sourdough. Sourdough is classified into four types: type I (traditional sourdough), type II (starter culture-initiated sourdough), type III (dried sourdough), and type IV (mixed dry sourdough) [9].

The study utilizes types I and III sourdough. Type I sourdough, referred to as wet sourdough (before drying), consists of three variations: W (mineral water and wheat flour), G (papaya fermented water, sugar, and wheat flour), and P (fermented papaya water and wheat flour). Wet sourdough is then dried to reduce water content, extend shelf life, and enhance its usability in bread production. Drying is performed using 3 methods: spray dryer (S), cabinet dryer (C), and freeze dryer (F).

Bread is one of the most widely consumed bakery products worldwide. Commercial instant yeast, readily available in markets, is frequently used as leavening agent in bread-making, accelerating fermentation for faster and more consistent production. Wheat flour, derived from whole wheat, is a primary ingredient in bread. It contains phytic acid, which is not broken down by instant yeast and can inhibit the absorption of essential minerals such as calcium, magnesium, and iron [10]. In addition, phytic acid interferes with starch and protein digestion by inhibiting digestive enzymes, potentially causing gastrointestinal discomfort and posing health risks for individuals with autoimmune intestinal disorders, such as celiac disease. To enhance mineral absorption, alternative ingredients should be used in bread-making. One such ingredient is sourdough, which contains yeast and lactic acid bacteria. Lactic acid bacteria break down sucrose to produce exopolysaccharides, which enhance the bread's volume, texture, and fiber content. This study aims to evaluate the impact of drying on pH levels, Total Titratable Acidity (%TTA), LAB viability, and yeast viability. Additionally, it examines how drying affects the specific volume and texture profile of both gluten-containing and gluten-free bread.

2. Materials and Methods

2.1. Materials

The ingredients used to make sourdough are California papaya *(Carica papaya* L.*)* from Sleman, Indonesia, sugar (Gulaku, Indonesia), wheat flour (Cakra Kembar Premium, Indonesia), and mineral water (Aqua, Indonesia). Bread ingredients include wheat flour (Cakra Kembar Premium, Indonesia), rice flour (Bola Deli, Indonesia), tapioca flour (Rose Brand, Indonesia), potato flour (Point, Indonesia), psyllium husk (Gluck Manamart, Indonesia), chicken eggs, margarine (Blue Band, Indonesia), salt (Dolphin, Indonesia), granulated sugar (Gulaku, Indonesia), and baking paper (Chefy). The materials used for sample analysis include distilled water, rice grains, MRS broth (Merck, Germany), dextrose (Merck, Germany), yeast extract (Merck, Germany), peptone (Oxoid), NaCl (Merck, Germany), NaOH (Merck, Germany), phenolphthalein indicator (Merck, Germany), and bacteorological agar (Merck, Germany).

The equipment used in this study includes a standing mixer EKM3437W (Electrolux, Sweden), an electric oven KBO-200 (Kirin, Indonesia), a texture analyzer-TA 1 series (LLOYD, UK), a spray dryer B-290 (BUCHI, Switzerland), a cabinet dryer (Futake, Indonesia), a freeze dryer (Labconco, US), a pH meter (Mettle Toledo, US), a burette (Pyrex, US), petri dishes (Pyrex, US), conical tubes (Gosselin, Germany), erlenmeyer flasks (Pyrex, US), beakers (Pyrex, US), measuring cups (Pyrex, US), a laminar flow cabinet (Esco, US), an autoclave (Gea, Indonesia), a sterilization oven (Memmert, Germany), baking sheets, a digital scale (Taffware, Indonesia), and other kitchen equipment.

2.2. Fermentation starter of papaya fruit

Fermentation was conducted using two samples: P (papaya and water) and G (papaya, sugar, and water). The preparation of P samples involved peeling the papaya, cutting the fruit, placing 100 g of papaya in a glass jar, adding 250 g of mineral water, and sealing the jar tightly. For G samples, 100 g of papaya was combined with 250 g of mineral water and 20 g of granulated sugar before sealing the jar. Both P and G samples were fermented for 30 hours at 30°C [11] .

2.3. Type I of sourdough making

To prepare Type 1 sourdough, 30 g of wheat flour was mixed with a starter (P, G, or W) and fermented at 30°C for 24 hours. After 24 hours of fermentation, 30 g of sourdough was weighed for the feeding process, in which it was mixed with mineral water and wheat flour at a 1:2:2 ratio every 12 hours for three days until it matured. The resulting sourdough could then be dried, chemically analyzed, microbiologically examined, or used for bread-making [11]. Three different starter types of water were used to prepare type I sourdough: P (fermented water from papaya and wheat flour), G (fermented water from papaya, sugar, and wheat flour), and W (mineral water and wheat flour).

2.4. Type III of sourdough making

Type III sourdough was produced by drying mature type I sourdough using three methods: freeze drying, cabinet drying, and spray drying.

2.4.1. Spray drying

The sourdough was diluted with distilled water (1:5) and homogenized using an ultra thorax for five minutes. The homogenized mixture was then dried using a spray drier, which converted the sample into dry powder by spraying it through a nozzle at an inlet temperature of 130°C and an outlet temperature of ±95°C [12].

2.4.2. Cabinet drying

In the cabinet drying process, sourdough was spread in a thin layer on a 24 x 24 x 2 cm baking pan covered with baking paper. The pan was then placed into a cabinet dryer and dried at 50°C for 24 hours. The resulting dry sample was subsequently ground into powder [13].

2.4.3. Freeze drying

25 g of sourdough were placed in a 100 ml plastic cup, sealed with aluminum foil, and perforated with small holes to carry for freeze drying. The sample was then frozen in a freezer for at least 12 hours before being dried in a freeze dryer at -45°C and 0.096 mbar for 30 hours. The resulting dry sample was then ground into powder [12].

2.5. Bread making

Prepare the following ingredients: 200 g of wheat flour, 3 g of sugar, 3.6 g of salt, 119 g of mineral water, 9.8 g of margarine, and either 18 g of type I sourdough or 10 g of type III sourdough. This is the first step in bread-making. Once all ingredients are prepared, mix them using a standing mixer for ten minutes, then let the dough rest for four hours. After the rising process, shape the dough, place it in a baking dish, and bake at 200°C for 50 minutes [11].

2.6. Analysis of the pH value of sourdough

To analyze the pH, dilute 10 g of sourdough with 90 ml of distilled water and measure it using a pH meter [14].

2.7. Analysis of the total titrated acid value of sourdough

The total titrated acidity (%) is used to analyze the chemical properties of sourdough. To measure %TTA, dilute 10 g of sourdough in 90 ml of distilled water, add 2-3 drops of phenolphthalein indicator, and titrate with 0.1 N NaOH until the pH reaches 8.2 [14].

2.8. Analysis of the microbiological properties of sourdough

The microbiological properties of sourdough were analyzed using measuring yeast viability and lactic acid bacteria (LAB) viability. Total LAB were analyzed by homogenizing 10 g of sample in 90 ml of 0.85% NaCl solution and diluted to the correct concentration. Then, 1 ml of the diluted sample was plated on de Man Rogosa Sharpe Agar (MRSA) and incubated at 37°C for 48 hours before colony counting. For the total yeast analysis, 10 g of the sample was homogenized in 90 ml of 0.85% NaCl solution and diluted to the appropriate concentration. Then, 1 ml of the diluted sample was plated on yeast extract peptone dextrose (YPD) agar and incubated at 30°C for

48 hours before colony counting [15].

2.9. Analysis of the physical properties of bread

2.9.1. Analysis of the specific volume

The specific volume of white bread was determined following the AACC (2000) method using the rape seed displacement technique, as described in [16]. The specific volume (cm3/g) was calculated by dividing the bread's volume by its mass [16].

2.9.2. Analysis of the texture profile

A Texture Analyzer was used for Texture Profile Analysis in accordance with AACC (1999). To measure hardness, gumminess, chewiness, cohesiveness, springiness index, and resilience, bread was sliced into a thickness of ± 2 cm and compressed to 50% of its original height at a speed of 0.5 mm/s [11].

2.10. Experimental design

The research was conducted using a randomized block design. pH value, %TTA, LAB viability, and yeast viability were measured before and after the drying process. Subsequently, bread was made using a randomized block design with the type of bread and drying treatment (before and after) as factors in the measurement of specific volume and texture profile analysis. All analyses were performed in duplicate.

2.11. Statistical analysis

Data were analyzed using IBM SPSS 22.0. A T-test was performed to compare the results of each sample before and after the drying process, with statistical significance determined accordingly.

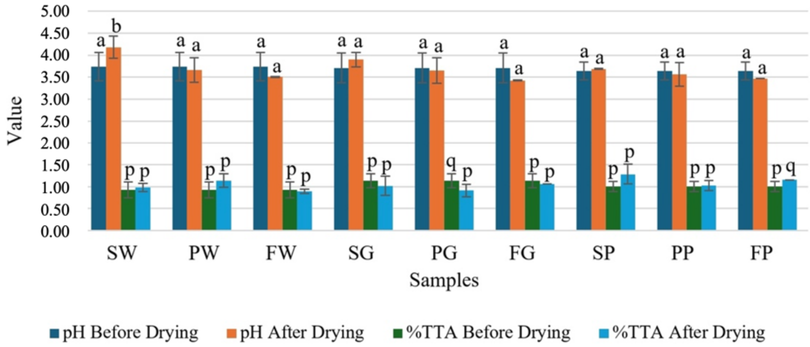
3. Results and Discussion

3.1. The pH value and %total titrated acid of sourdough

The pH value and %Total Titrated Acid (TTA) of sourdough before and after drying are presented in Fig. 1.

According to the T-Test results, the pH value of sample W was significantly affected by the spray-drying method ($p < 0.05$), while the cabinet and freeze-drying methods had no significant effect ($p > 0.05$). In contrast, the pH values of G and P samples were not significantly affected by any of the drying methods ($p > 0.05$).

Before drying, the initial pH values of the sourdough were 3.74 ± 0.32 for sample W, 3.71 ± 0.34 for sample G, and 3.64 ± 0.20 for sample P. The pH of the three samples after spray-drying increased compared to their pre-drying levels and other drying methods. Wieschebrock et al. [17] also reported that spray-drying results in higher pH values than roll-drying or fresh dough. In contrast, freeze-dried samples had lower pH values than spray-dried ones, consistent with findings by Caglar et al. [18], who observed similar trends using the same sourdough samples.



Notes:

- Different notations show significantly different results (Sig. < 0.05)
- S: spray drying; C: cabinet drying, F: freeze drying
- W: water; G: papaya + sugar; P: papaya

Fig. 1. The pH Value and %Total Titrated Acid of Sourdough

Tafti et al. [19] reported that fresh sourdough had a higher pH than spray-dried sourdough when made with wheat flour, tap water, and *Lactobacillus paralimentarius*. However, this study yielded different results, likely due to the use of spontaneous fermentation with a natural papaya starter, whereas the previous research incorporated controlled culture, potentially influencing fermentation. Similarly, Tafti et al. [20] discovered that the pH of fresh wheat flour sourdough was higher than that of spray-dried sourdough. In their study, wheat bran was incorporated into the sourdough to raise its ash content, potentially influencing the pH level after drying. The pH values of the three samples of dried sourdough were lower than those of fresh sourdough. The cabinet drying, which required a full day at relatively low temperatures, may have contributed to the pH reduction. However, no relevant study has specifically examined the pH measurement of dehydrated sourdough samples. In addition, dried sourdough typically exhibits a lower pH than fresh sourdough due to its higher water absorption, which decreases stability [20,21].

According to the T-Test Statistical Test (Before and After Drying Sample), the %TTA sample W was not significantly affected by spray-drying, cabinet-drying, or freeze-drying (Sig. > 0.05). In the G samples, spray-drying and freeze-drying did not significantly affect the %TTA (Sig. > 0.05), while cabinet drying resulted in significant effect (Sig. < 0.05). For the P samples, spray-drying and cabinet dryer did not significantly affect the %TTA (Sig. > 0.05), while freeze-drying had a significant effect (Sig. < 0.05).

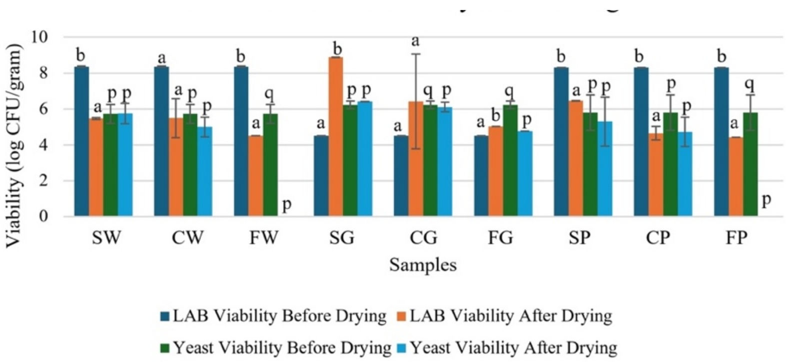
The amount of 0.1 N NaOH required for titration until the sample turns pink and reaches the desired pH indicates that the total titrated acid depends on total organic acid production in the sourdough [22]. Research by Restuningtyas [4] found that the total titrated acid of papaya sourdough is lower than that of water sourdough. This finding aligns with the present study, which also shows that the total titrated acid (%) of sourdough with papaya fermented water is lower than that of water sourdough.

This research showed that the freeze-drying method in P samples and the spray-drying method in W and P samples had higher %TTA than fresh sourdough. This findings align with a study by Caglar et al. [18], which reported that freeze- and spray-drying techniques had higher %TTA than fresh sourdough. Additionally, total titrated acid (%) in sourdough produced with tap water, wheat flour, and *Lactobacillus paralimentarius* indicates that spray-dried sourdough had a higher %TTA than fresh sourdough [19].

This study showed different results for the spray-drying method in the G samples and the freeze-drying method in W and G samples, which showed a lower %TTA than fresh sourdough. This may be caused by the variations in the initial chemical composition of the samples, leading to differences in %TTA after drying [18]. In this research, samples W and P showed a higher %TTA than the G after cabinet drying, whereas G had a lower %TTA than fresh sourdough. However, no relevant studies have specifically examined the determination of total titrated acid (%) in cabinet-dried sourdough samples.

3.2. Microbiological characteristics of type I & III sourdough

Fig. 2 presents the viability of lactic acid bacteria (LAB) and yeast in sourdough before and after drying.



Notes:

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- W: water; G: papaya + sugar; P: papaya

Fig. 2. Lactic Acid Bacteria and Yeast Viability of Sourdough

According to the T-Test results (before and after drying per sample), cabinet drying had no significant effect on LAB viability (log CFU/gram) (Sig. > 0.05). However, spray-drying and freeze-drying significantly impacted LAB viability (log CFU/gram) (Sig. < 0.05) in samples W and G. In sample P, spray-drying, cabinet dryer, and freeze-drying, had significant effects on LAB viability (log CFU/gram) (Sig. < 0.05).

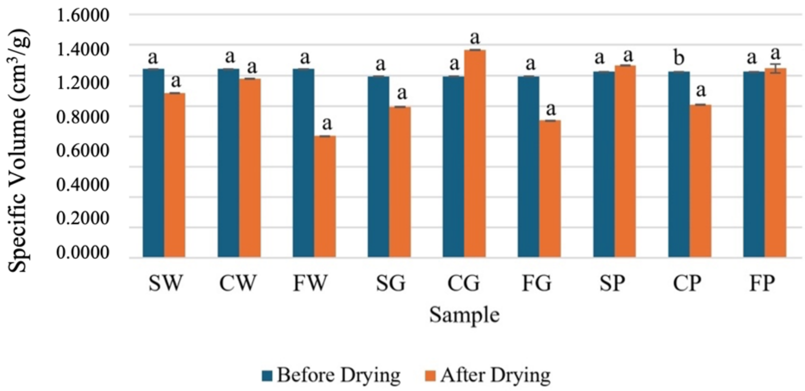
The T-Test results (before and after drying) shows freeze-drying had significant effects on yeast viability (log CFU/gram) (Sig. < 0.05), while spray-drying and cabinet dryer did not significantly affect samples W and P. In sample G, both freeze-drying and cabinet drying had significant effects on yeast viability (log CFU/gram; Sig. < 0.05), while spray-drying did not significantly affect the yeast viability.

The results show that adding papaya fermented water to sourdough decreases the viability of lactic acid bacteria compared to using water alone. This contrasts with Restuningtyas [4], who reported higher lactic acid bacteria viability in papaya sourdough (10.63 ± 0.24 log cfu/g) than in water sourdough (9.36 ± 0.66 log cfu/g). This discrepancy may be due to variations in the papaya used, which prevented the fermentation process from producing the ideal lactic acid bacteria. However, in mature sourdough, an increase in height, the formation of voids, and a detectable fermentation aroma were observed. Differences in fruit nutrition composition, such as the presence of simple sugars that inhibit lactic acid bacteria growth may also contribute to this difference [4].

The study results show that adding papaya-fermented water to yeast sourdough increases its viability compared to using water alone. This aligns with findings by Restuningtyas [4], which reported higher yeast viability (10.36 ± 0.02 log cfu/g) than in water sourdough (9.11 ± 0.25 log cfu/g).

In samples W and P, LAB viability decreased after drying, likely due to drying method [18]. Meanwhile, in sample G, no reduction in lactic acid bacteria viability was observed, possibly due to the protective effects of sugars, which also served as a nutrient source for bacterial survival. Tafti et al. [19], reported that spray-drying reduces LAB viability due to heat and dehydration during the heating phase. In addition, Wieschebrock et al. [17] found that LAB cells can only be identified by real-time PCR after drying, as they are no longer viable. Freeze-drying also reduces cell viability, as freezing at low temperatures before drying halts cell growth and damages cells during the drying process [23].

Osmotic shock causes cell injury by disrupting hydrogen bonds in cell membranes, potentially altering the structure of hydrophilic macromolecules [24,25].



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- Different notations show significantly different results (Sig. < 0.05)
- S: spray drying; C: cabinet drying, F: freeze drying
- W: water; G: papaya + sugar; P: papaya

Fig. 3. The Results of Specific Volume of Gluten Free Bread

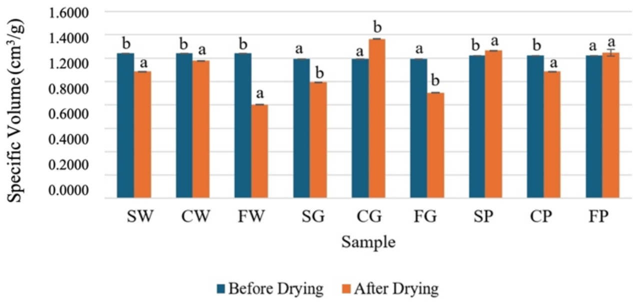
3.3. Physical characteristics of bread

3.3.1. Specific volume of gluten free and gluten bread

Specific volume is an important parameter to evaluate the bread's visual quality [18]. The specific volume of gluten-free bread is presented in Fig. 3, while that of regular bread is presented in Fig. 4.

The T-Test (before and after drying per sample) shows that the specific volume of gluten free bread was not significantly affected by spray-drying, cabinet dryer, or freeze-drying in samples W and G (Sig. > 0.05). However, a significant effect of the cabinet drying was found observed in the P sample (Sig. < 0.05), while freeze-drying and spray-drying had no significant impact (Sig. > 0.05).

The specific volume measurements of gluten-containing bread are presented in Fig. 4.



Notes:

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- S: spray drying; C: cabinet drying, F: freeze drying
- W: water; G: papaya + sugar; P: papaya

Fig. 4. The Results of Specific Volume of Gluten Bread

The T-Test (before and after drying per sample) shows that the specific volume of gluten-containing bread (cm^3/gram) was significantly affected by spray-drying, cabinet dryer, and freeze-drying in samples W and G (Sig. < 0.05). In the P sample, spray-drying and cabinet drying had a significant effect (Sig. < 0.05), whereas freeze-drying showed no significant impact on the specific volume (cm^3/g).

The findings on a specific volume of gluten free bread in this study contrast with previous research, which reported no statistically significant difference between the specific volumes of water sourdough and papaya sourdough bread [4]. Similarly, a study using snake fruit fermented water starter found no significant difference in specific volume between snake fruit sourdough bread and water sourdough bread [26]. Differences in the initial bacterial count of the sourdough may explain observed in this study compared to Restuningtyas [4], as bacterial composition can influence bread volume. In contrast, the specific volume of gluten-containing bread aligns with findings of Restuningtyas [4] and Agustina [26].

Caglar et al. [18], reported that the specific volume of bread made from freeze-dried sourdough is lower than that of spray-dried sourdough. However, the findings of this study contradict those of Caglar et al. [18], as the specific volume of bread from spray-dried sourdough sample A was lower than that of freeze-dried bread. This discrepancy may be attributed to variations in LAB and yeast activity caused by improper fermentation of the bread dough.

In terms of appearance, bread made with papaya sourdough has a more rounded shape compared to bread made with water sourdough [4]. The increase in bread dough volume is due to CO2 production by LAB metabolism and heterofermentative yeast in sourdough [4,27]. CO2 accumulation during fermentation enhances the dough's ability to retain gas [4,11]. However, sourdough addition can lower pH value during fermentation, inhibiting baker's yeast from producing CO2 during proofing, which lowers bread volume and results in a firmer crumb [28].

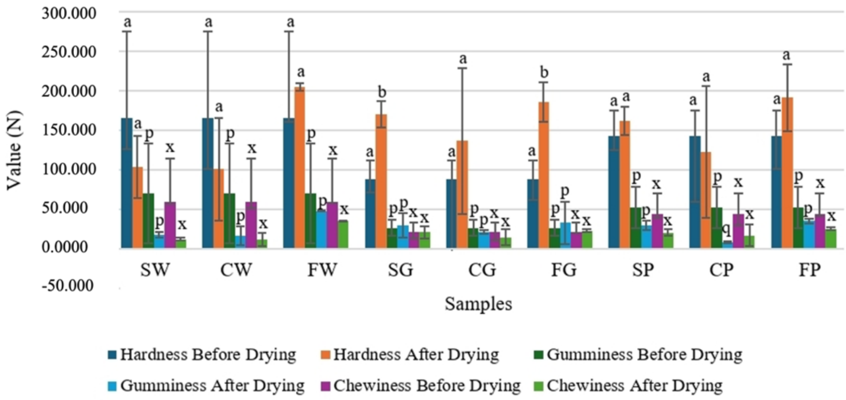


Fig. 5. The Hardness, Gumminess, and Chewiness of Gluten Free Bread

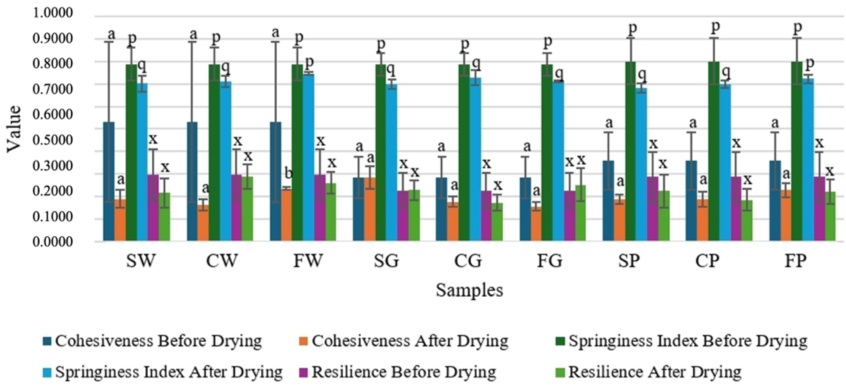


Fig. 6. The Cohesiveness, Springiness Index, and Resilience of Gluten Free Bread

3.3.2. Texture profile of gluten-free and gluten bread

The texture profile analysis of gluten-free bread and gluten bread are presented in Fig. 5, Fig. 6, Fig. 7, and Fig. 8. The bread deformation process is determined by mean cell area and crumb structure, both of which affect the bread hardness. According to Marinotti et al. [29], as crumb structure becomes denser and the mean cell area decreases, hardness increases, requiring more energy for deformation. These findings contradict those of Restuningtyas [4], who reported a significant difference in the hardness of papaya sourdough bread compared to water sourdough bread. Variations in pore size may explain these differences. While Restuningtyas [4] found that papaya sourdough bread had higher hardness due to its high cell density and small pore size, the visual results of this study show that papaya sourdough bread has significantly larger pores than water sourdough bread, leading to a lower hardness value.

This research shows a significant difference in the hardness value of fresh and dried sourdough. As a result, freeze-dried sourdough bread has a higher hardness value than spray-dried sourdough bread. These findings align with those of Caglar et al. [18], who reported that freeze-dried sourdough bread has greater hardness than spray-dried sourdough bread. Additionally, variations in hardness may arise between sourdough and dough made with acidifying agents [18,30]. The drying process affects microbial activity, hardness, and the sourdough's bread-making potential. In addition, hardness value is influenced by the presence of lactic acid bacteria metabolites, such as exopolysaccharide, which contribute to lower hardness. The difference in hardness between papaya sourdough bread and water sourdough bread is likely due to variations in LAB strains that produce exopolysaccharides [4].

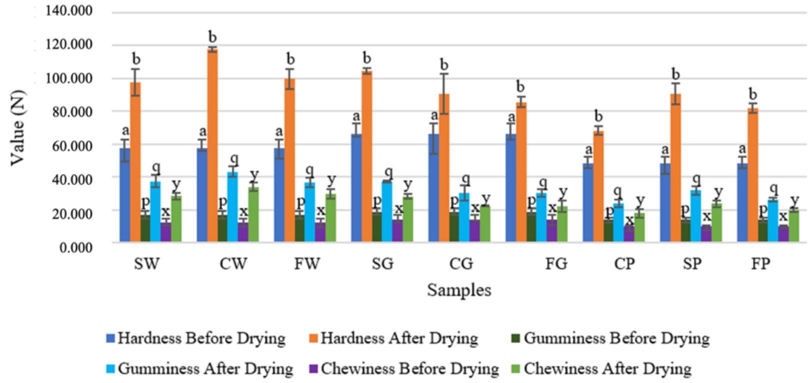
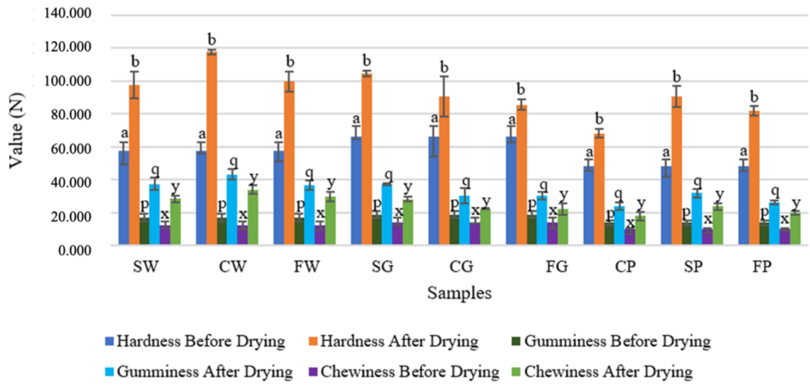


Fig. 7. The Hardness, Gumminess, and Chewiness of Gluten Bread

Supasil et al. [31] found that the chewiness of water sourdough bread fermented with pear and Assam tea leaves did not significantly different from sourdough bread. Similarly Restuningtyas [4] reported no significant difference in gumminess and chewiness between papaya sourdough bread and water sourdough bread.



Notes:

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- S: spray drying; C: cabinet drying, F: freeze drying
- W: water; G: papaya + sugar; P: papaya

Fig. 8. The Cohesiveness, Springiness Index, and Resilience of Gluten Bread

The type of starter did not significantly affect the gumminess, chewiness, cohesiveness, springiness index, or resilience of gluten-free bread, nor the springiness index of gluten bread. However, it significantly affected these parameters in gluten bread and the springiness index of gluten bread. In addition, the gumminess, chewiness, cohesiveness, springiness index, and resilience in both gluten-free and gluten bread.

According to Onyango et al. [32], cohesiveness indicates the degree of disintegration during mastication, with higher values signifying less disintegration and lower values leading to more crumbling. This study found that all dry sourdough bread crumbled more than fresh sourdough due to its lower cohesiveness value. A product's freshness and crumb brittleness are related to the springiness index, with brittleness increasing as springiness decreases [33]. Resilience and elasticity are related, with their measurement based on the area under the curve ratio. A decrease in springiness and resilience reduces bread's crumb elasticity [32]. The study found that all dry sourdough bread had lower resilience and springiness values than fresh sourdough, indicating higher crumb brittleness and changed the crumb elasticity.

4. Conclusions

Spray-drying significantly affected the pH value of the A sample and LAB viability in the W and G samples. Cabinet drying significantly affected %TTA and yeast viability in the G sample. Freeze-drying methods had a significant effect on the LAB and yeast viability in the W and G samples, as well as yeast viability, and %TTA in the P sample.

Instant sourdough is produced by using spray, cabinet, and freeze-drying methods and can be used for both gluten-free and gluten-containing bread. Variations in starters and drying methods influence the bread's physical characteristics, including specific volume and texture profile. Spray, cabinet, and freeze-drying significantly affect hardness, gumminess, chewiness, cohesiveness, springiness index, and resilience in both gluten-free and gluten-containing bread sample.

Abbreviations

S	spray drying
C	cabinet drying
F	freeze drying
W	water
G	papaya + sugar
P	papaya
TTA	total titrated acid
LAB	lactic acid bacteria

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Rini Yanti. conceptualization, methodology, funding acquisition, resources, drafting the manuscript, revising the manuscript for significant intellectual content. **Dian Anggraini Suroto**: conceptualization, methodology, funding acquisition, resources, revising the manuscript for significant intellectual content. **Manikharda**: conceptualization, methodology, funding acquisition, resources, revising the manuscript for significant intellectual content. **Yuniar Wika Perdana Putri**: acquisition and analysis of data, drafting the manuscript.

Declaration of Competing Interest

The authors of this manuscript declare no conflict of interest or competing interest.

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