International Journal of Applied Pharmaceutics

ISSN- 0975-7058 Vol 14, Special Issue 5, 2022

Original Article

EFFECT OF HEAT TREATMENT ON POTASSIUM CONTENT AND ANTI-SHIGELLOSIS ACTIVITY OF KLUTUK BANANAS (*MUSA BALBISIANA* COLLA) FRUIT FLOUR

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Received: 10 Sep 2022, Revised and Accepted: 06 Nov 2022

ABSTRACT

Objective: to investigate the effect of heat treatment on the potassium content and anti-shigellosis action of klutuk banana fruit flour.

Methods: The klutuk banana fruit slices were heat-treated using a validated oven under varied parameters of 30-50 °C for 15–40 h. Based on its minimum inhibitory concentration (MIC) value and the potassium analysis, the selected condition was then applied to the processing of bananas to produce stable flour. Atomic Absorption Spectrophotometry (AAS) was used to quantify the potassium concentration after the MIC value was calculated using the microbroth dilution method.

Results: The best heat treat for the anti-shigellosis activity with a MIC of 3.125 mg/ml was at 50 °C for 20 h. The amount of potassium in the flour of klutuk banana fruit that had the best anti-dysentery activity was 0.3773 mg/ml or 9.76% of the total potassium content. But according to our research, the lower water content of banana flour caused by longer drying times and higher temperatures had no effect on the existence of antimicrobial metabolites.

Conclusion: The potassium gain and anti-shigellosis action of klutuk banana fruit were thus significantly impacted by heat during the flour-processing stage.

Keywords: Klutuk, *Musa balbisiana* colla, Heat, Potassium, Shigellosis

DOI: https://dx.doi.org/10.22159/ijap.2022.v14s5.10 Journal homepage: https://innovareacademics.in/journals/index.php/ijap

INTRODUCTION

Banana fruit is one of the traditional medicines that, according to evidence, can treat dysentery. Secondary metabolites such flavonoids, polyphenols, tannins, quinones, saponins, monoterpenoids, and sesquiterpenoids found in klutuk banana fruit have the potential to limit bacterial development. Our earlier studies demonstrated that the fruit of Klutuk banana possessed a strong antibacterial activity against *S. dysenteriae* and might be further developed to be an anti-shigellosis product [1]. This is intriguing because banana klutuk's utilization has not been optimal up until this point due to its seeds, thick skin, and inability to use the fruit in its raw state [2, 3]. Nevertheless, they have a limited shelf life and must be processed further to have a longer shelf life. Therefore, due to their perishable nature, bananas must undergo additional processing to create other goods, such as banana flour. The advantages of processing bananas into banana flour include lengthening the period of storage, using them as adaptable raw materials, enhancing distribution security, and making them a useful material for processing [4]. As in our previous study, the unripe old banana fruit demonstrated higher anti-shigellosis activity than the ripe ones and it is more easier to make it into banana flour. Banana flour is recognized to provide some of the nutrients the body requires, including starch (84%), protein (6.8%), fat (0.3%), ash (0.5%), and food fiber (7.6%), in addition to being more durable [5]. To keep those nutrients, the banana flour must be high quality. Bananas are dried with sunshine or a drying device to produce flour, which is then ground and sieved through a mesh size of 100 [6]. To make it impossible for enzymes to function and for microorganisms to thrive, the water content was reduced by the drying process. Food preservation is the purpose of drying which is the surface area, heating temperature, air flow rate, and air pressure are variables influencing drying success [7]. However, it is well recognized that heat treatment can cause large losses of molecules with biological activity [8]. The findings demonstrated that thermal treatment have an impact on potassium availability as a result of changes in mineral structure [9]. Therefore, the stability of the natural contents of the flour must be considered in the process of flour making.

Banana fruit flour which is rich in many nutrients and mineral content, can be used to make a variety of large-scale pharmaceutical products with a tremendous medical benefit. It may be possible to create ready-to-eat anti-shigellosis product items with high and combine bioactive substances using the flour from klutuk bananas. Finding novel anti-dysentery medications has been more popular recently because of the rise in disorders caused by multidrug resistance germs [10, 11]. *S. dysentriae* infection healing became more challenging as incidences of resistance to many possible medications increased. WHO recommended the medicine trimetoprim-sulfametoxazol for the treatment of basilar dysentery. However, *S. dysenteriae* instances resistant to trimetoprim-sulfametoksazol have been discovered [12]. Additionally, *S. dysentriae* has demonstrated resistance to tetracycline, chloramphenicol, ampicillin, and kotrimoksazol [13]. Dysentery-related diarrheal episodes are more likely to persist than those that start with watery stools with high frequency and the potential to cause dehydration. A frequent electrolyte disease called hypokalemia is brought on by variations in potassium intake, abnormal excretion, or transcellular shifts [14]. One of the components that contribute to the body's ability to regulate its acid-base balance and electrolyte balance is potassium [15]. When the potassium in plasma levels is less than 3.5 mEq/l, dehydration will take place [16]. Normal levels of potassium in serum range from 3.5 to 5.0 mEq/l. Delays in treating dehydration contribute to mortality in certain dysentery patients [17]. Despite having antimicrobial metabolites, banana fruits have also been described as a natural supply of potassium, with 78 mg per 100 g [18, 19]. Thus, it can prevent dehydration brought on by increased frequency of diarrhea because dysentery disease is a significant contributor to the morbidity and mortality of diarrhea. Although it does not shorten the frequency or length of diarrhea, oral rehydration therapy (ORT) has been recognized as a critical element in the fall in child mortality rate due to diarrhea [20]. So, in addition to acting as an antidysentrial medication, the ethanol extract of banana fruits can deliver potassium and stop hypokalemia-related dehydration. In light of the prevalence of resistant instances and the vital roles potassium plays in the body, it is imperative to look for natural antidysentrica that can also provide a potassium hypokalemia preventative.

MATERIALS AND METHODS

Plant material

Based on the flower blooming period, the fruit of the 3-month-old Klutuk banana was harvested and used as a sample in this study; it was collected in Gedebage, West Java, Indonesia. The plant sample was recognized in the Plant Taxonomy Laboratory Padjadjaran University.

Validation of oven

The calibrated thermometer was positioned 50 mm from the walls in the corners of the empty oven. Additionally, a second calibrated thermometer was positioned in the oven's geometric center. The temperature was then set and the oven was shut. It was permitted for the oven's temperature to stabilize. The oven was opened once it had steadied, and the temperatures on the thermometer were noted. It was given time to stabilize with the oven closed. Record the oven's temperature after it has steadied. Reset the controls and repeat the process if the oven temperature is not at the desired level [21].

Flour production preparation

The fruits and skins of klutuk bananas were separated after being cleaned and allowed to air dry at room temperature [22]. The klutuk banana fruits were divided into pieces that were about 1 mm thick, 2-3 cm long, and 2-3 cm wide. Before drying, the fruit slices were then put on aluminum foil.

Thermodynamic and time optimization of drying

Fruit slices were placed on aluminum foil and dried in an oven at different temperatures (30, 40, and 50 °C) and times (15, 20, 24 and 40 h). The water content of dried fruits was determined using a loss and drying method after the drying process.

Analysis of loss on drying

To determine the temperature and duration of drying that result in dried fruit slices with the desired level of water content, a loss on drying analysis was carried out. Weighing 1-2 g of dried fruits in a bottle that had been heated to the set temperature served as the basis for the loss on the drying test. The dried fruits were then shaken flat in the bottle to create a layer 5 to 10 mm thick. Dried fruit-filled bottles were put into the oven with their tops open. Fruits were dried until the weight became constant at the setting temperature. The dried fruits with the required amount of water were then blended and sieved through a 100-mesh screen to produce the flour from Klutuk banana fruit.

Phytochemical screening of secondary metabolites

Phytochemical analysis of secondary metabolites was performed using a conventional procedure to identify the presence of alkaloids, flavonoids, tannins, quinones, saponins, steroids, and triterpenoids in both the simplisia and flour of Klutuk Banana Fruits [23].

Bacterial suspension preparation

One Ose of *S. dysenteriae* colony was removed from slant agar and floated into sterile physiological saline as part of the preparation process. Measurement of bacterial turbidity using a typical 0.5 Mc Farland [24].

Antibacterial activity test

The klutuk banana fruit's antibacterial activity was tested using the agar diffusion method and a perforation technique. To create a solution with a 100 mg/ml concentration, banana fruit flour was dissolved using DMSO as a solvent. In a sterile petri plate, 20 µl of bacterial suspension (equal to 0.5 Mc Farland) was first placed into the dish, and then 20 ml of MHA was added. The medium was uniformized and given time to set up. To allow for the storage of the flour in each concentration of 100 µl, the medium was perforated. All media tests were incubated for 18–24 h at 37 °C [24].

Statistical analysis

The inhibitory diameter data from the antibacterial activity test was processed with SPSS 17 software using a factorial design to analyze the influence of the concentration of klutuk banana fruit flour towards the potent inhibition against *S. dysentriae* and to ascertain the optimal drying conditions in order to obtain temperature and drying time data that provided the best antibacterial activity. If the test with the factorial design generated significant findings, then continued with the Tukey test. Tukey's test was used to examine the difference in the ability of each flour concentration to the inhibitory zone generated [25].

Determination of MIC and MBC value

The MIC value of the flour was calculated using the microdilution technique. Each column on the microplate was filled with 100 µl of MHB altogether. Only the MHB medium made up the positive control, which was put in the first microplate well. In the meantime, the 12th microplate well was filled with the negative control, which contained the media that had been injected with the test bacteria. The flour stock solution was diluted with 20 mg/ml Dimethyl sulfoxide (DMSO) to get a test concentration of 100 mg/ml, and the diluted flour stock solution was then pipetted into the second well and homogenized. Additionally, up to 100 µl of the mixture from the second well was pipetted onto the third column, where it was subsequently homogenized. After then, the procedure is repeated and applied progressively till the 11th well. After that, each well was inoculated with the *S. dysentriae* suspension at a concentration of 5×10^5 CFU/ml up to 100 µl, resulting in a concentration of 5×10^4CFU/200 µl of bacteria in the second to last well. After that, the test medium was incubated at 37 °C for 18 to 24 h. The lowest concentration column, which resulted in a clear test medium that did not exhibit bacterial growth, was then spread for 10 µl on MHA medium and cultured for 18 to 24 h at 37 °C. The number of bacterial colonies that had grown were counted. The maximum number of colonies that can expand as the MBC value is the concentration that inhibits 99.9% of the final inoculum concentration [24].

Quantitative measurement of potassium level

Atomic absorption spectroscopy (AAS) was used to analyze the samples after they had first been prepared using the dry destruction method. One gram of klutuk banana fruit flour was measured out, then put in the furnace at a temperature of 600 °C until the flour turned into ash. Then the ash was added with 10 ml 6.5% HNO_3 and heated on a hot plate. After that, the mixture was filtered into a 25 ml volumetric flask and the filtered filtrate was added with demineralized water. The test sample solution is ready to be measured. In that, the standard potassium solutions must be prepared to develop a calibration curve. One gram of solid KCl was weighed and dried for 2 h at 100 °C and then cooled for 30 min. Then 25 mg of KCl was weighed and put into a 25 ml volumetric flask. The volumetric flask was then filled to the mark with demineralized water, shaken to ensure that all of the solutions were uniform, and a stock solution of 1 mg/ml was produced. The standard potassium solution is diluted to various concentrations with the addition of demineralized water. The absorbance of the diluted standard solution was measured using AAS. The blank used for measurement is demineralized water. Absorbance measurement was conducted by inserting a hose into the standard solution with the lowest concentration to the highest concentration. The measurement results are recorded and linear regression calculated so that a straight-line equation is obtained to see the linearity [26].

RESULTS

Based on the information in table 1, the verified oven's differential temperature ranged from 0.5 to 1.5 °C. The oven needs 40 to 45 min to reach a steady temperature. Since the temperature difference shown by the oven is no greater than 5 °C, the oven utilized has been validated.

The weight of klutuk banana fruit was calculated both before and after drying in order to determine the percentage of weight loss. The weight loss percentage for the klutuk banana fruit is shown in table 2.

Loss on drying

The quality of dried Klutuk banana fruits was also controlled by a loss on drying test [26]. Table 3 displays the results of the drying test on the fruit of the Klutuk banana.

Table 1: Oven validation

Test temperature oven (°C)	Thermometer temperature (°C)	Time temperature stability (min)
30	30.5±0.09	40±0.00
40	41.5±0.04	45±0.00
50	51.5±0.00	45±0.00

Values represent mean±SD, n=3.

Table 2: Percentage of weight lost

Temperature (°C)	Drying time (h)	Initial weight (g)	Final weight (g)	Lost weight (g)	Lost weight (%)
30	15	25.05±0.02	21.07±0.02	3.98	15.89
	20	25.06±0.00	19.06±0.01	5.99	23.93
	24	26.32±0.01	16.31±0.00	10.01	38.03
	40	25.16±0.00	9.88±0.00	15.28	60.74
40	15	26.58±0.00	17.47±0.02	9.11	32.27
	20	26.41±0.00	12.91±0.02	13.50	51.13
	24	26.96±0.00	9.23±0.00	17.74	65.77
	40	26.98±0.01	2.62±0.00	24.36	90.29
50	15	25.43±0.01	8.54±0.00	16.88	66.40
	20	25.37±0.02	2.62±0.00	22.74	89.65
	24	25.68±0.00	2.91±0.00	22.77	88.65
	40	25.88±0.00	3.53±0.00	22.35	86.35

Values represent mean±SD, n=3.

Table 3: Percentage of loss on drying

Temperature (°C)	Drying time (h)	Initial weight (g)	Final weight (g)	LOD value (%)
30	15	1.97±0.00	0.14±0.00	92.64
	20	1.96±0.00	0.20±0.00	89.90
	24	1.97±0.00	0.26±0.00	86.91
	40	1.98±0.01	0.47±0.00	76.47
40	15	1.85±0.02	0.23±0.00	87.73
	20	1.87±0.00	0.32±0.00	82.83
	24	1.89±0.00	0.48±0.00	74.73
	40	1.87±0.00	1.66±0.00	10.92
50	15	1.71±0.00	0.65±0.00	62.01
	20	1.79±0.00	1.63±0.00	8.79
	24	1.80±0.00	1.69±0.00	6.21
	40	1.89±0.00	1.79±0.00	5.42

Values represent mean±SD, n=3.

Phytochemical screening result

According to the information in table 4, there were no differences in the secondary metabolites between simplisia and banana flour. The phytochemical study of these flours revealed a variety of components, including polyphenol, tannins, quinones, flavonoids, saponins, monoterpenes, and sesquiterpenoids. The presence of these secondary metabolites may contribute to the antibacterial action of klutuk banana fruits against *S. dysenteriae*.

Table 4: Phytochemical screening result

Metabolites	Simplisia	Flour
Alkaloids	-	-
Quinones	+	+
Polyphenols	+	+
monoterpenoids	+	+
sesquiterpenoids	+	+
Tannins	+	+
Flavonoids	+	+
Steroid and Triterpenoid	-	-
Saponins	+	+

Antibacterial activity results

The longer the drying time, the less the diameter of the inhibitory zone increased, as shown by the results in table 5. The highest inhibitory zone was found in banana klutuk flour that had been dried for 20 h. According to the temperature and drying time of a material, the difference in the diameter of the inhibitory zone may result from the breakdown of the active ingredient.

Table 5: Antibacterial activity results of klutuk fruit flour at drying temperature of 50 °C

Drying duration (h)	Flour concentration (mg/ml)	Diameter of inhibition (mm)
20	100	24.67±0.11
	50	21.95±0.22
	25	18.53±0.12
	12.5	12.11±0.16
24	100	23.85±0.35
	50	21.52±0.19
	25	17.99±0.13
	12.5	11.70±0.11
40	100	23.04±0.11
	50	20.71±0.13
	25	17.15±0.14
	12.5	11.63±0.10

Note: Perforator diameter = 9 mm, Values represent mean±SD, n=3.

Statistical analysis

A factorial design was used to statistically examine the impact of concentration and drying time on the diameter of the inhibitory zone. Table 6 displays the outcomes of the factorial design test.

Further study was done using the Tukey test to determine which period of time and concentration has the best antibacterial activity. Tables 7 and 8 contain the findings of the Tukey test.

The diameter of the inhibition zone caused by differences in concentration and variations in drying time exhibits a significant difference where the values in the subsets are not in the same column, according to the Tukey test results in Tables 7 and 8. The Tukey test findings show that a 20 h drying period at a specific temperature offers the optimum antibacterial action. As opposed to this, a concentration of 100 mg/ml produces the best antibacterial action.

Results of MIC and MBC determination

The MIC is defined as the endpoint concentration of the extract in the first tube at which bacterial suspension clearly emerges as a clear solution. However, when at least two of the tubes used to represent the MIC are sub-cultured and counted, the lowest concentration indicating either no colony development or the death of 99.9% of the original colonies; this concentration is known as the MBC value. Table 9 shows the results of determining the MIC and MBC of klutuk fruit flour. These test findings demonstrate that klutuk banana flour at a drying temperature of 50 °C for 20, 24, and 40 h has the same range of values for both the MIC and MBC, the value of 3.125 mg/ml.

Table 6: Statistical analysis result

Source	Type III sum of squares	df	Mean square	F	Sig.
Corrected Model	746.845	11	67.895	526.805	0.000
Intercept	12642.379	1	12642.379	98093.764	0.000
Time (A)	8.416	2	4.208	32.649	0.000
Concentration (B)	737.179	3	245.726	1906.622	0.000
Time* Concentration (AB)	1.250	6	0.208	1.616	0.186
Error	3.093	24	0.129		
Total	13392.317	36			
Corrected total	749.938	35			

Table 7: Effect of drying time on antibacterial activity

Time	N	Subset		
		1	2	3
3	12	18.134167		
2	12		18.7675	
1	12			19.3175
Sig.		1	1	1

Notes: Drying time: (1) 20 h; (2) 24 h; (3) 40 h.

Table 8: Effect of concentration on antibacterial activity

Concentration	N	Subset			
		1	2	3	4
4	9	11,814444			
3	9		17,892222		
2	9			21,396667	
1	9				23,855556
Sig.		1	1	1	1

Notes: Concentration of Klutuk banana flour: (1) 100; (2) 50; (3) 25; (4) 12.5 mg/ml

Potassium level calculation

The potassium levels in fruit flour are then examined using the linear regression equation y = 0.00085 x+0.01213 with a correlation coefficient of 0.998232, which was created by making a standard potassium solution with concentrations of 0.1; 0.2; 0.3; 0.4 and 0.5 mg/ml and measuring its absorbance. The test findings showed that the fruit flour had the best antibacterial action in the drying condition of 50 °C, 20 h, a potassium level of 0.3773 mg/ml, and a potassium content percentage of 9.76%.

Table 9: MIC and MBC determination

Duration of drying (h)	Concentration (mg/ml)	MIC	MBC
20	50	-	-
	25	-	-
	12.5	-	-
	6.25	-	-
	3.125	-	-
	1.5625	+	+
	0.7812	+	+
	0.3906	+	+
	0.1953	+	+
	0.0976	+	+
24	50	-	-
	25	-	-
	12.5	-	-
	6.25	-	-
	3.125	-	-
	1.5625	+	+
	0.7812	+	+
	0.3906	+	+
	0.1953	+	+
	0.0976	+	+
40	50	-	-
	25	-	-
	12.5	-	-
	6.25	-	-
	3.125	-	-
	1.5625	+	+
	0.7812	+	+
	0.3906	+	+
	0.1953	+	+
	0.0976	+	+

DISCUSSION

Banana flour is produced primarily for the following reasons: it is more durable in storage, can be utilized as a flexible raw material, increases distribution process safety, and is a useful material for processing [4]. Making it into banana flour also has the advantage of obtaining additional nutrients, including starch (84%), protein (6.8%), fat (0.3%), ash (0.5%), and food fiber (7.6%) [5]. However, since it may be exposed to environmental contaminants during production, storage, and shipping, banana flour must be of high quality to be used as a raw material product. As expected, the flour's surface may become contaminated. According to reports, the abrasion that occurs during the milling process can lower the quantity of pollutants in flour [28]. However, it found out that the milling procedure was unable to guarantee the flour's safety as a product free of impurities. According to a different study, bacteria are widespread and are responsible for many illnesses linked to diet [29]. A proper flour drying procedure can be a crucial endeavor to protect flour quality from contamination. The most crucial phase in processing plant-based raw materials was drying because it could impact the quality of the finished goods. In this study, oven drying was chosen over direct sun drying because it produces products of higher quality. Because there will be a rapid reduction in the amount of water, drying in an oven was thought to be more advantageous [27, 30]. Considering that the presence of water might promote the development of microbes, particularly fungi. Reducing the water content can stop the action of microbial enzymes. Surface area, heating temperature, air flow velocity, and air pressure are variables that affect drying success [7]. Therefore, the stability improvement of the oven temperature was selected as one of cases of this study to be validated. According to the findings, the validated oven's differential temperature ranged between 0.5 and 1.5 °C and took 40 to 45 min to stabilize, as shown in table 1. This study found that increasing the drying temperature and duration closely correlated with the percentage of weight lost. The percentage of weight lost as a result of drying was also raised by higher drying temperatures and longer drying times, as presented in table 2. The percentage of weight loss was, however, inversely proportional to the drying temperature and time at some specific drying temperatures and times. Moisture content, water activity, and the ratio of a substance's water vapor pressure to pure water under equal conditions are all significant elements in the safety and stability of items as they are being manufactured. Good-quality simplisia had a water content of less than 100 mg/ml and had the qualities of being simple to break, free from mold, and smelling like new materials. Based on the information in table 3, the drying condition with the temperature of 50 °C in its drying times of 20, 24 and 40 h met the requirement as good simplisia.

As the effect of heat treatment, we must consider the stability of the phytochemical components in the flour in addition to its water content. A longer period of high-temperature heating can harm the phytochemical compounds that are used as the active ingredients in a product. Table 4 displays the results of the phytochemical screening. It was discovered that the secondary metabolites in banana flour and simplisia were identical. This demonstrated that the drying conditions utilized in this study—temperature and duration—did not have an impact on the existence of secondary metabolites. But it might have an impact on the phytochemical substances level, as predicted by observing the result of antibacterial activity, presented in table 5. The duration of heat treatment or drying provided different inhibitions against *S. dysentriae*. The amount of each secondary metabolite in flour can have an impact on how effective this banana flour is at preventing dysentery. Statistically, it was found that according to the findings of the factorial design, which are shown in table 6, drying time and concentration both have an impact on the diameter of the inhibitory zone. The value of sig. = 0.000, which has a value less than the level of significance (= 0.05), demonstrates this. However, it appears that there is no relationship between drying time and concentration and the diameter of the inhibition zone based on the value of sig = 0.186, which is bigger than the real level (= 0.05). The initial hypothesis (H0) is rejected, as evidenced by the significant value (sig. value), which is less than the real level (= 0.05). From table 7 and 8, the Tukey test findings show that a 20 h drying period at a specific temperature offers the optimum antibacterial action.

Each phytochemical compound contained in the klutuk banana flour, whether used singly or in combination, exhibits antibacterial activity with a variety of mechanisms. The results of literature studies suggested that secondary metabolite compounds such polyphenols, flavonoids, tannins, saponins has the activity of antibacterial with various working mechanism. Numerous studies have reported that flavonoids have a variety of antibacterial mechanisms, including the inhibition of nucleic acid synthesis, interference with cytoplasmic membrane and energy metabolism, reduction of bacterial adhesion to form biofilms, disruption of porin, and decrease in membrane permeability [31-35]. Shigella spp. caused microbial infection is a problem for the medical community. Therefore, since bacterial biofilm development has received a lot of attention recently and since microbial cells formed in biofilms are more resilient to environmental stresses like dehydration and oxidation, tannin compounds are crucial in terms of their mode of action [36]. The lipophilic terpenoids has antibacterial activity by destroying the bacterial cell membrane, it will react with the active side of the membrane, dissolving the lipid constituent and increasing permeability [37]. Then, the antibacterial action of saponins focuses on reducing the permeability of bacterial membrane cells [38, 39].

Despite possessing anti-shigellosis metabolites, Klutuk banana fruits have been characterized as a natural source of potassium. Because dysentery disease significantly contributes to the morbidity and mortality of diarrhea, it can therefore avoid the dehydration brought on by increasing the frequency of diarrhea. Based on the results of the analysis of potassium levels, klutuk banana fruit flour with the best antibacterial activity (50 °C, 20 h) had a potassium content of 0.3773 mg/ml with a percentage of potassium content of 9.76%. This potassium value sourced from the flour form was higher than that of the ethanolic extract (2.919%). The finding is in line with the study, which reported that heat treatment can improve potassium availability because of the mineral structure changes [9]. From the selection of the heat treatment condition, the potassium content of the flour can still meet the body's potassium needs. The body requires 15-25 meq of potassium which is equivalent to 0.585-0.975 g/l or 0.0585%-0.0975% [40]. Therefore, it can be concluded that klutuk banana fruit flour with the best antibacterial activity (50 °C, 20 h) has the potential as a natural source of potassium.

MIC-MBC is regarded as a benchmark number for determining how susceptible an organism is to antibiotics [41]. *S. dysentriae* inhibited in the concentration of 3.125 mg/ml. The MBC test findings showed that 99.9% of the tested bacteria were killed at the same concentration as the MIC. From these data, we can categorize the resulting klutuk banana flour as bactericidal agents, due to its ratio of MBC/MIC were being ≤4 [42, 43]. The important thing is that the MIC-MBC value of Klutuk banana fruit flour was lower than that of the ethanolic extract form with the MIC-MBC value of 50-100 mg/ml [44]. This finding demonstrated that the concentration of antibacterial phytochemicals can be more stable due to the lower water content caused by heat treatment in the making process of flour. The discovery of novel bactericidal qualities in klutuk banana flour encourages the development of new strategies to deal with multidrug-resistant *S. dysentriae*.

CONCLUSION

According to the results of this study, heat treatment has the ability to boost anti-shigellosis action and potassium availability from the flour of Klutuk banana fruit in comparison to ethanolic extract form. Therefore, potassium gain and anti-shigellosis action of klutuk banana fruit were thus significantly impacted by heat during the flour-processing stage. In contrast to processing it into extract form, this tendency shows that there is a chance to supply klutuk banana antibacterial products with production that is simpler, less expensive, and long-lasting but has an effective anti-shigellosis action and is a natural potassium provider.

FUNDING

Nil

AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

CONFLICT OF INTERESTS

Declared none

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