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3 The characteristics of “indigenous yeast mold” dried culture using tray dryer

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Abstract. This research studied the effect of temperature and drying time in making “Indigenous Yeast Mold” dried culture using tray drier. There are 2 dried culture, names AC and CC. AC consists of 3 mold and 1 yeast strains, while CC consists of 7 mold and 3 yeast strains. The temperature of drying used were 40°C and 50°C and the drying time were 0, 1.5, 3, 4.5, and 6 hours. The results showed that the quality of dried cultures AC and CC were influenced by the drying times and temperatures. The water content, viability of microorganisms, A_w , and pH value decreased with the increasing of drying time and temperature. The drying time at the temperature of 40°C affected the water content and water activity of AC and CC dried culture significantly. While the drying time at the temperature of 50°C affected the moisture content, water activity, viability of microorganisms, and pH value of AC and CC dried culture significantly. The desired water content in dried culture is 10% (wb) or 11.1 (db). To reach the water content of 10%, at the drying temperature of 40 °C, the AC dried culture required 4.46 hours, while CC required 4.44 hours. Meanwhile, at the drying temperature of 50 °C, the AC dried culture took 3.46 hours, while CC required 3.33 hours. Drying could be done at 50 °C without changing the quality of the dried culture.

1. Introduction

The results of fermented flour from local white corn flour [1] showed that the fermentation process changes the characteristics of native white corn flour. Likewise [2] have fermented corn grits using different types of starters produce 1 different characteristics of white corn flour compared to the characteristics of their native flour. The use of indigenous yeast and mold in the form of starter cultures require special expertise and are difficult to apply in the community. To overcome this problem and facilitate the fermentation process, researcher [3] has made a dried culture consisting of indigenous yeast and mold. The use of this dried culture in the manufacture of fermented white corn flour produced corn flour which has the characteristics tend to fried products and products that are consumed hot such as cream soup and raw materials for instant porridge, sauce, custard, and bread.

The dried culture that contain indigenous yeast and mold have made using an oven as a dryer [3]. At present, the drying method of culture has increasingly developed such as the use of vacuum drying methods, spray drying, freeze drying, and the fluidized bed dryer method [4]. In addition, researcher 1 [5] has dried a mixture of tempeh culture using tray dryer at a temperature of 50°C for 3 hours. Tray dryer can reduce the drying surface area and increase the efficiency of hot air contact to the material. This

condition caused the air circulation in the drying chamber between the racks giving the same results [6]. Tray dryer was chosen to dry the indigenous yeast and mold culture because it is expected to be a more effective drying method. Based on the research of [3] that drying the indigenous yeast mold culture using oven at temperature of 40°C and solar drying produced the best dried culture with high water content (13.34% and 12.5%) and required a long time (48 hours and 7 days). Based on this, the purpose of this study was to determine the time length and temperature of the drying of indigenous yeast and mold culture using a tray dryer. The characteristics of the indigenous yeast mold dried culture that desired are the water content 10% or less, the total viability of yeast molds is at least 10^6 CFU/g, water activity values range from 0.51-0.89, and pH ranges from 2–8.5 [3].

2. Materials and Methods

2.1. Microorganisms

Microorganisms used as a CC starter culture were *Penicillium chrysogenum*, *Penicillium citrinum*, *Aspergillus niger*, *Rhizopus stolonifer*, *Rhizopus oryzae*, *Fusarium oxysporum*, *Acremonium strictum*, *Candida famata*, *Kodamaea ohmeri*, *Candida krusei/ incopticua*, while AC starter culture contain *Penicillium citrinum*, *Aspergillus niger*, *Acremonium strictum*, and *Candida famata*. The microorganisms used were previously isolated and identified from a spontaneous fermentation of corn grits [7].

2.2. Culture preparation and enumeration

One loop of each mold was streaked onto fresh Potato Dextrose Agar (PDA) slant and then incubated at 30°C for five days. After five days, molds were harvested by scrapping, suspended in 10 mL sterile water and appropriately diluted for enumeration using haemocytometer. Yeast culture was prepared as above, but incubation was carried out at 30°C for two days. Yeast enumeration was also carried out using haemocytometer [1].

2.3. The process of making AC-indigenous yeast mold culture (Modified [7] and [3])

Growing medium used in making yeast and mold culture was corn flour. According to [3] this medium produced the highest total yeast mold culture compared to other mediums (rice and tapioca flour). The technique of making yeast mold culture includes the stages: sterilizing corn flour, then put it into a sterile basin and adding sterile distilled water as much as 2/3 of the total weight of corn flour. Prepared culture suspensions (AC and CC) containing 10^6 CFU / mL per microorganism, then piped as much as 10% of the amount of water used. After that, all stirred until homogeneous and put \pm 17 grams in each petri dish. Petri dishes were then incubated at 30 °C for 5 days. Furthermore, the dough is dried using a tray dryer with a temperature of 40 °C dan 50 °C for 0, 1.5, 3, 4.5, and 6 hours. The dried AC-indigenous yeast mold culture is made powder using a blender that has been sprayed with 70% alkohol. The AC-indigenous yeast mold culture powder was packed in plastic clips with silica gel, and then tested for water content, viability (total number of yeast molds), water activity, and pH. The process of making the AC and CC indigenous yeast mold culture powder can be seen in Figure 1.

2.4. AC-CC indigenous yeast mold culture analysis

The product produced is tested for the response. The responses observed were viability (CFU/g) [8], moisture content (thermo-gravimetry) [9], water activity (A_w meter Rotronic Hygrolab) [9], and degree of acidity (pH meter Orion Thermo-Scientific) [9]. The quality indicator was that (1) the water content was equal to or less than 10%; (2) the total viability of yeast molds was at least 10^6 CFU / g; (3) A_w values range from 0.51-0.89; and (4) pH ranges from 2–8.5 [3].

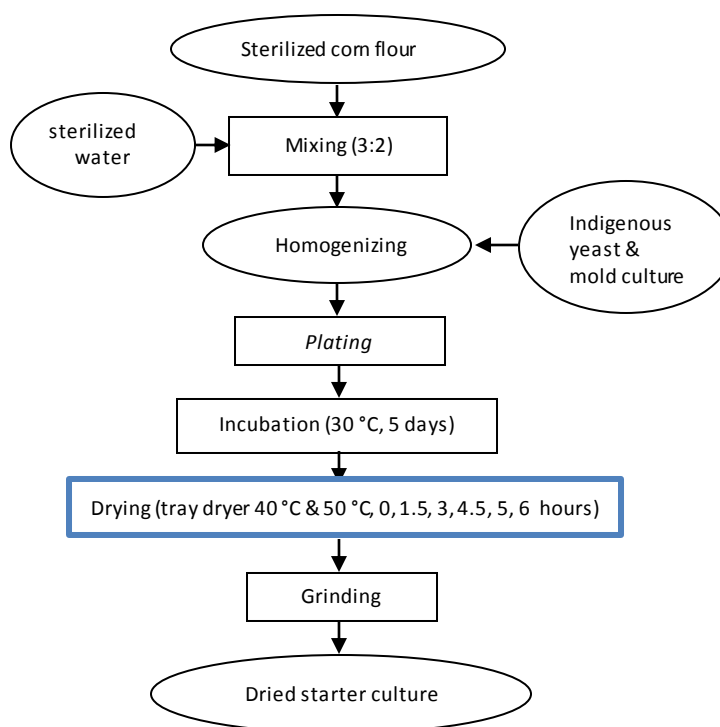


Figure 1. The process of making AC and CC-indigenous yeast mold dried culture (Modified [7] and [3]).

2.5. Statistical analysis

Obtained data was then processed using ¹⁰ t-test and ANOVA with SPSS (*Statistical Package for the Social Sciences*) software to analyze the influence of drying time and temperature of drying process.

3. Results and discussion

The characteristics of the indigenous yeast mold dried culture that desired are the water content 10% or less, the total viability of yeast molds is at least 10^6 CFU/g, water activity values range from 0.51-0.89, and pH ranges from 2–8.5 [3].

3.1. Influence of drying process on water content

The initial moisture content of the AC dried culture ranges between 55.97 - 56.81% and the CC is between 51.46 - 55.46%. After drying the moisture content of the AC ranged between 5.52-7.35% and CC between 4.90-8.40%. In general, the temperature and drying time reduce the water content. When the temperature increase, the water content will decrease. Likewise, when the drying time getting longer, the water content will decrease too (Figure 2 and 3).

Drying process of indigenous yeast mold culture was expected to reduce the water content to 10% or less. Water content determines the shelf life of the product because it determines the availability of water in food for microorganisms life [10]. The statistical test results showed the exponential equation for AC at temperature of 40°C is $y_1 = 97.998e^{-0.512x}$ and the CC is $y_2 = 78.556e^{-0.489x}$. The y variable represents the water content and x is the drying time. Based on these equations, it was found that the drying time needed to reach 10% of moisture content was $x_1 = 4.46$ hours for AC and $x_2 = 4.22$ hours for CC at the drying temperature of 40°C. Whereas the exponential equation for AC at a temperature of 50°C is $y_3 = 95.162e^{-0.651x}$ and the CC is $y_4 = 83.036e^{-0.636x}$. The drying time needed to reach 10% moisture content was $x_3 = 3.46$ hours for AC and $x_4 = 3.33$ hours to CC at a drying temperature of 50 °C.

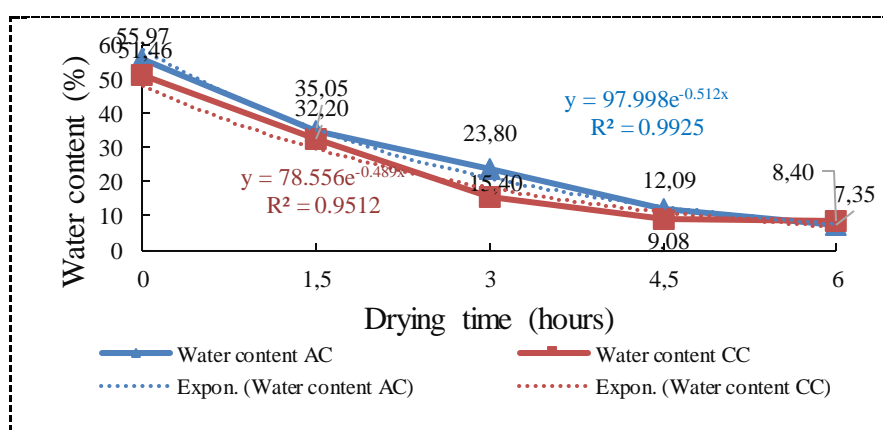


Figure 2. Changes in water content of AC and CC dried culture during drying time at temperature 40°C.

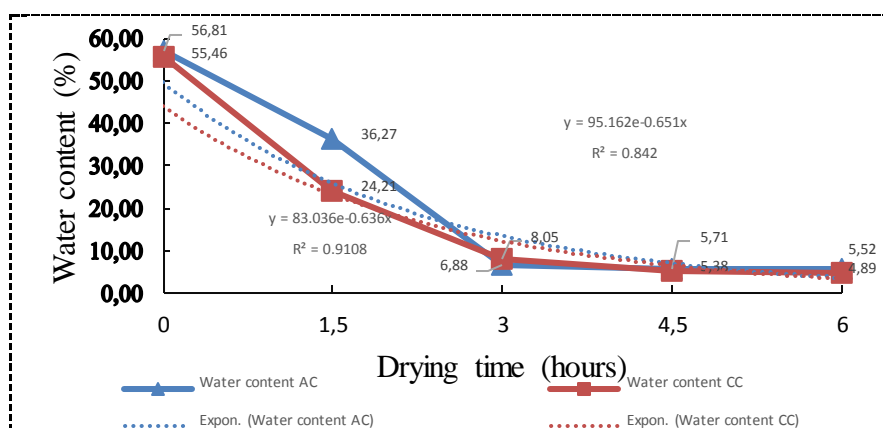


Figure 3. Changes in water content of AC and CC dried culture during drying time at temperature 50°C.

Drying process at 40°C results the drying rate of AC culture faster than CC. This can be seen at the value of the constant. Constants that have higher values will have a faster of the drying rate. The CC dried culture reached the 10% water content faster than AC, while the drying rate was slower (CC required 0.24 hours faster than AC). This was because the initial water content of the CC (51.46%) is lower than AC (55.97%). In addition, AC dried culture consisted of 4 isolates while CC 10 isolates. It caused the cell mass of CC dried culture larger and denser than AC, so it dried faster. Drying process at 50°C showed that the AC dried culture had a faster drying rate than CC, but the CC reaches a moisture content of 10% faster. CC drying time was 0.13 hours faster than AC. The initial water content of both dried culture relatively the same, so the difference in drying time was also relatively the same. Drying time of AC culture at a temperature of 50°C was faster than at a temperature of 40°C to reach 10% moisture content as well as CC dried culture. This was caused by the drying rate at a temperature of 50°C was higher than at a temperature of 40°C. A higher drying rate also caused the time needed is faster.

The results of the T-test showed that the drying temperatures of 40°C and 50°C produced different water levels which were not significant in the AC temperature, but were significantly different in the CC dried culture (p value = 0.031). This means that drying process can be done at temperatures of 40°C and 50°C because it produced a different water content that was not significantly different. Beside that, drying process of CC dried culture at temperatures of 40°C and 50°C produced water content that was significantly different. Therefore, choosing the drying temperature is needed to get the desired moisture content for CC dried culture.

Water content decreased during longer drying time. The ANOVA showed that the drying time affected the moisture content of AC dried culture at a temperature of 40°C, where water content at each drying time was significantly different (p value = 0.000) as well as the CC dried culture (p value = 0.000). Likewise drying at a temperature of 50°C, where the drying time affected the moisture content of AC and CC dried culture. This was indicated by the existence of significant differences at each drying time (p value = 0.000). This difference indicated the drying process is going well because the water content in the dried culture is reduced. Drying at temperature 50 °C reaches 10% moisture content faster than 40°C.

This was in line with research [11] where the temperature higher and the the drying time longer, the water molecules will evaporate more from the dried material so that the water content obtained gets lower. The ability of the material to release water from its surface will be greater with the higher the temperature of the dryer used and the longer the drying process, so the lower the water content produced.

3.2. Influence of drying process on viability of microorganisms

The initial viability of microorganisms in AC dried culture ranged from 8.90 - 9.14 log CFU / g (db), where CC dried culture contain 8.82 - 9.20 log CFU / g (db). During the drying process the viability of microorganisms in the AC and CC dried culture were decreasing with higher temperatures and longer drying times (Figures 4 and 5). Table 1 showed the moisture content and viability of microorganisms in the AC and CC dried culture at temperatures of 40°C and 50°C during drying.

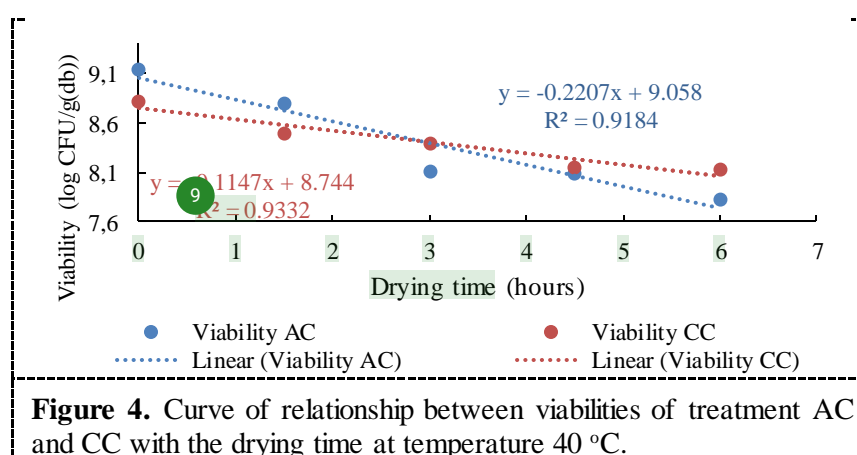
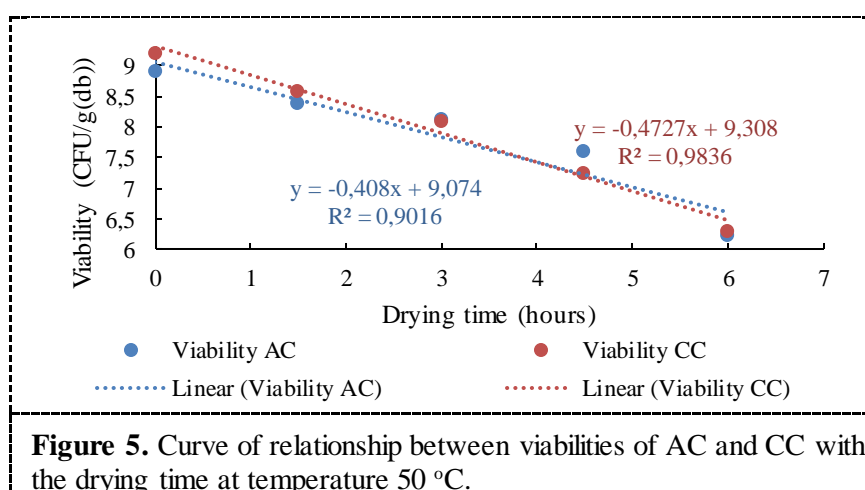


Figure 4. Curve of relationship between viabilities of treatment AC and CC with the drying time at temperature 40 °C.

Based on the exponential equations in Figures 2 and 3, the time needed to reach the water content of 10% at drying temperatures of 40 °C for AC dried culture is 4.46 hours and the CC is 4.22 hours, while at 50 °C for AC is 3.46 hours and CC 3.33 hours. Viability of microorganisms is around 8.10 log CFU / g (db) for AC and 8.16 log CFU / g (db) for CC dried culture to reach 10% moisture content with temperature of drying of 40 °C. Where at a temperature of 50 °C the viability of microorganisms in the AC dried culture between 7.60 - 8.14 log CFU / g (db) and CC contains microorganisms between 7.25 - 8.10 log CFU / g (db). The value of the viability is above the minimum requirement for the viability of microorganisms in dried culture (10^6 log CFU / g). Based on this, the drying of AC and CC can be carried out at 50 °C because the drying time is faster and the viability is still above the minimum requirement.



The T-test dependent showed that the viability of total yeast mold in the AC and CC dried culture over the two different drying temperatures is not significantly different. This showed that the drying of AC and CC dried culture at temperatures of 40°C and 50°C did not affect the viability of the AC and CC dried culture. The decreasing of microbial viability is influenced by the heat resistance of microbes, where each microbe has a different heat resistance. Microbial heat resistance, expressed as a D value. D value is the time in minutes at a certain temperature needed to reduce the number of spores or certain vegetative cells by 90% or one logarithmic [12]. The calculation results showed that the D value of AC and CC at temperatures of 40°C is 271.86 minutes (4.5 hours) and 523.10 minutes (8.7 hours) respectively, while at 50°C is 147.06 minutes (2.45 hours) and 127.93 minutes (2.13 hours) respectively. This D value is influenced by temperature. When the temperature higher, the D value will be smaller [13]. This was in line with the results of the calculation of the D value of AC and CC dried culture at a temperature of 40°C and a temperature of 50°C. Meanwhile, the rate of decline of microorganisms is determined by the value of k. The rate of decline of microorganisms in the AC and CC dried culture is faster at 50 °C with k values of 0.408 and 0.4727 while at 40 °C the rate of decline is slower with k values of 0.2207 and 0.1147 respectively. This showed that the AC and CC dried culture are more heat resistant at 40 °C.

Table 1. Viability (log CFU / g) and moisture content (% db) of AC and CC dried culture at different temperatures and drying times.

Drying time (h)	Temperature 40 °C				Temperature 50 °C			
	AC		CC		AC		CC	
	Water content (% db)	Viability (Log CFU/g)	Water content (% db)	Viability (Log CFU/g)	Water content (% db)	Viability (Log CFU/g)	Water content (% db)	Viability (Log CFU/g)
0	127.12 ^d	9.14	106.02 ^d	8.82	131.54 ^c	8.90 ^c	124.52 ^e	9.20 ^b
1.5	53.96 ^d	8.79	47.49 ^c	8.50	56.91 ^b	8.38 ^b	31.94 ^d	8.58 ^a
3	31.23 ^c	8.12	18.20 ^b	8.39	7.39 ^a	8.14 ^a	8.75 ^c	8.10 ^a
4.5	13.75 ^b	8.10	9.98 ^a	8.16	6.05 ^a	7.60 ^a	5.70 ^b	7.25 ^a
6	7.93 ^a	7.83	9.18 ^a	8.13	5.84 ^a	6.23 ^a	5.15 ^a	6.32 ^a

The ANOVA results showed that at 40°C the viability of the AC dried culture was not significantly different at each drying time (p value 0.190), while the viability of the AC dried culture at 50°C was significantly different at each drying time (p value 0.000). This showed that the viability of the AC is stable during the drying process at a temperature of 40°C while it is not stable at 50°C. This was supported by a higher D value of AC dried culture at a temperature of 40°C and a small rate of

decline. The viability of AC and CC dried culture is stable because molds and yeasts tend to be able to survive during the period of drying process. In this research *Penicillium*, *Aspergillus*, *Rhizopus*, *Fusarium*, and *Candida* were used. In which *Penicillium chrysogenum* and *P. citrinum* are mesophilic and grow at temperatures of 5 - 40 °C with optimal temperatures of 26-30 °C ([14]; [15]; [16]); *Aspergillus*, grows at a temperature of 8-45 °C with an optimal temperature of 35-37 °C; *Rhizopus* grows at a temperature of 7-42 °C with an optimum temperature of 37 °C; while *Fusarium* grows at a temperature of 25-37 °C with an optimum temperature of 25-37 °C; and *Candida* grows at a temperature of 8-47 °C [16]. Drying at a temperature of 40 °C and 50 °C is not expected to affect the viability of the AC and CC dried culture. This correlates with the ability of mold and yeast to survive in dry conditions. Sunatmo [17] stated that mold and yeast can survive in agricultural products with low water content with water activity 0.80 - 0.88. Beside that, the drying temperature and time are factors that influence the decrease in the amount of long viability [5].

3.3. Influence of drying process on water activity (A_w)

The value of water activity (A_w) is important in food ingredients because it is a safety characteristic of food ingredients. Product that has a low A_w value will have the shelf life longer, because microorganisms can only live in certain A_w conditions [10]. The value of the water activity (A_w) at the beginning of the drying process ranged from 0.925 - 0.940 for the AC dried culture and 0.946 - 0.958 for the CC dried culture. In general the value of water activity decreased with the longer drying time, likewise the A_w value of the AC and CC dried culture (Figures 6 and 7). As explained above, the characteristics of the indigenous yeast mold dried culture that desired are the water content 10% or less, where to reach this condition, at drying temperature 40 °C it takes 4.46 hours for AC and 4.22 hours for CC dried culture. On drying 50 °C, it takes 3.46 hours for AC and 3.33 hours for CC dried culture.

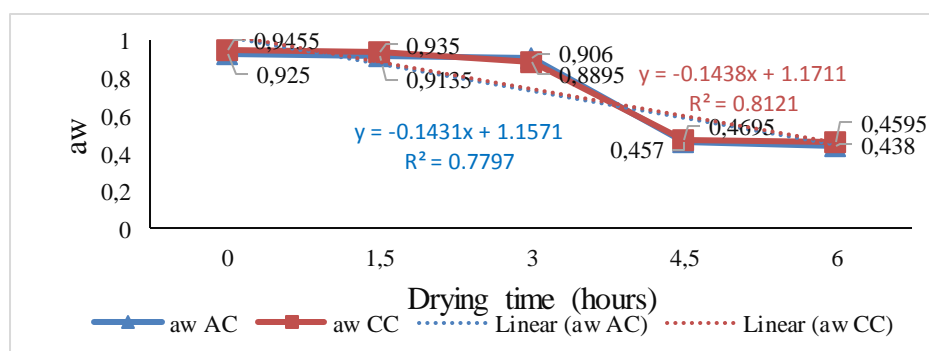


Figure 6. Changes in A_w value during drying time at temperature 40°C

Based on Figure 6 and 7, the linear regression equation for drying 40 °C for AC dried culture is $y_5 = -0.1431x + 1.1571$ and then CC is $y_6 = -0.1438x + 1.1711$. The linear regression equation for drying the temperature of 50 °C for AC line is $y_7 = -0.101x + 1.0763$ and then CC is $y_8 = -0.0758x + 1.0622$. From this equation, the A_w value of each dried culture under conditions of drying temperature when the water content reaches 10% can be calculated. The value of water activity when it reaches the water content of 10% at the drying temperature of 40 °C for the AC is $y_5 = 0.519$ and for the CC is $y_6 = 0.469$, while at the drying temperature 50 °C for the air AC is $y_7 = 0.727$ and the CC is $y_8 = 0.809$.

The T-test dependent results showed that the water activity value of the AC at the two drying temperatures was not significantly different (p value 0.225), as well as the value of water activity CC at both drying temperatures (p value 0.326). This showed that the drying time of AC and CC dried culture at temperature of 40 °C and 50 °C does not affect the characteristics of water activity dried culture. The ANOVA results showed that the drying time at 40 °C significantly affected the AC and CC water activity during drying process (p value 0.000). Likewise the drying time at 50 °C significantly affected the water activity value of AC and CC dried culture at each drying time (p value 0.000). Drying process of AC and CC dried culture at temperatures of 40 °C and 50 °C result the aw value significantly different (p value 0.000). This showed that the drying process of AC and CC dried culture at both drying

temperatures resulted in a significant decrease in a_w value at each drying time in accordance with [18] who stated that drying affects the decrease in moisture content of the material (A_w). In general, yeast molds can live at certain minimum A_w values. *Aspergillus* lives at a A_w value minimum of 0.98, *Rhizopus* 0.93, and *Penicillium* 0.99, where yeast can generally live at around 0.88-0.94 [19]. The results showed that yeast molds used were still able to live in a_w conditions. This is supported by the high viability value that is still high.

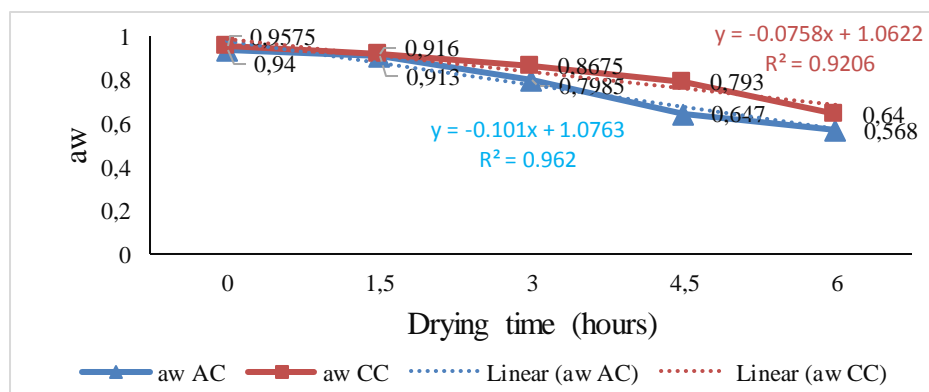


Figure 7. Changes in A_w value during drying time at temperature 50°C

3.4 Influence of drying process on the pH value

The pH value is the acidity degree used to express the acidity or alkalinity possessed by a substance, solution, or object. The initial pH value of AC dried culture ranges from 4.29 - 4.51 and the CC dried culture ranges from 4.00 - 4.22. During the drying process the pH of the AC dried culture decreased with the longer drying time, but the pH value increase in CC dried culture (Table 2).

The T-test dependent showed that the drying temperature of 40 °C and 50 °C had a significant effect on the pH value of the AC and CC dried culture (p value < 0.05). Whereas the ANOVA test results in which the drying time at 40 °C significantly affected the pH value of the AC, but did not affect the pH of the CC dried culture. On drying 50 °C, the drying time affects the pH value of the AC and CC dried culture significantly.

Table 2. The pH value of AC and CC dried culture over each temperature and drying time.

Time (h)	Temperature 40 °C		Temperature 50 °C	
	AC	CC	AC	CC
0	4.51 ^{ab}	4.00	4.29 ^a	4.22 ^a
1.5	4.37 ^c	4.36	4.38 ^c	4.32 ^a
3	4.35 ^{ab}	4.32	4.36 ^{bc}	4.56 ^b
4.5	4.32 ^{bc}	4.24	4.32 ^{ab}	4.73 ^c
6	4.00 ^a	4.20	4.35 ^b	4.65 ^c

Samples means with different superscripts in the same column are significantly different ($p < 0.05$) by Duncan's multiple range test.

The decreasing of pH of dried culture during drying time is related to the viability of microorganisms in dried culture. In general, yeast is more resistant to heat. *Candida krusei* can live at a temperature of 8-47 °C, while molds can grow optimally at a temperature range of 25-37 °C [16]. In addition, yeast is generally tolerant of acid and can grow at pH 4.0 - 4.5, with growth temperatures 0 °C - 50 °C, with optimum temperatures of 20 °C-30 °C [16]. The pH value of dried culture is in accordance with the pH of the dried culture when it reaches the water content of 10%. Low pH values can inhibit

contamination of decomposing microorganisms and pathogenic microorganisms. Low pH values also affect the aroma of the final product [20]. The longer time of fermentation caused a decrease in pH value in fermented sweet potato flour. This is because in the fermentation process there is a metabolism of the activity of microorganisms that produce organic acids [21]. The pH value of the AC and CC was around the pH of 4.00 which is in the pH range for the growth of microorganisms. The pH value was produced because it was fermented at the same time, 5 days.

4. Conclusion

Drying of AC and CC dried culture could be done using a tray dryer. Drying temperature and time influenced the quality of AC and CC dried culture, where temperatures (40 °C and 50 °C) and drying time (0, 1.5, 3, 4.5, and 6 hours) influenced the water content, microorganism viability, water activity and pH value of the AC and CC dried culture. The higher the temperature and the longer the drying time caused the moisture content, the viability of microorganisms, the value of aw and pH to decrease. The length of drying time at a drying temperature of 40 °C caused the moisture content and water content of the AC and CC dried culture to decrease significantly, while viability and pH were not significant. The length of drying time at a drying temperature of 50 °C caused the moisture content, viability, aw and pH of the AC and CC to decrease significantly. Drying is expected to reach water content of 10% (bb) or 11.1% (bk). To reach 10% moisture content, drying at 40 °C takes 4.46 hours for AC and 4.22 hours for CC, while at drying temperature 50 °C the time needed for the AC is 3.46 hours and for CC is 3.33 hours. Drying could be done at a temperature of 50 °C without changing the specifications of the dried culture.

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