Effects of Electrochemical Activated Water During Germination on Moisture and Diastase Activities of Germinated Wheat and Paddy

Nguyen Van Hung*, Tran Hong Anh, Vu Thi Tho

Hanoi University of Science and Technology – No. 1, Dai Co Viet Str., Hai Ba Trung, Ha Noi, Viet Nam
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Abstract

Electrochemical Activated (EA) Water has been studied and applied in many fields such as medicine, agriculture and food. Using anolyte solution pH 2.5-4.0 for disinfection allows to reduce the microorganism contamination. Catolyte solution pH 8.5-10.5 was used for soaking grains and replenishing moisture during germination. Grains were soaked at temperatures of 20, 25, 30^oC to reach a moisture content of 40-43%. Study germination at 15, 20, 25 oC for 4 to 6 days. Determining suitable regimen for harvesting wheat malt and paddy malt using electrochemical activated water solution, is to soak grains at 25 ^oC and grains germination at 20^oC and paddy grains soak and germination at 25^oC. The results of the study showed that the suitable condition for malt production as follows: wheat was washed in anolyte solution pH 2.5-4.0, then soaked in catolyte solution at 25^oC to reach moisture of 40-43% and germinated at 20^oC/ 96-104h, the diastase activity was highest. Paddy was washed in anolyte solution, soaked in catolyte solution at 25^oC, then germinated at 25^oC/ 130h in catolyte solution.

Keywords: Electrochemical activated water, wheat, paddy, germinated, malt.

1. Introduction

Different cereals contribute to the diversification of malts, the important sources of enzymes from the cereals for malt beverages [1,3]. These diverse sources of raw materials are precursors to the development of new foods and beverages different in properties and flavors, contributing to the increasingly diverse needs of consumers [15, 18, 24]. Thus, malt production technology has been increased to improve the malt quality, suitable for each material, towards reducing production costs [1, 5, 6, 7, 15].

One of the most important purposes of malt production is to activate the synthesis and accumulation of enzymes, especially hydrolysis enzymes. In many studies, the use of electrochemical activated water in malt production brought the positive effect,in increasing of malt diastase activity [6, 7, 22].

A number of researches aimed to improve the quality of malt byusing ultrasound, high frequency waves, seed treatment with direct current, magnetic or using biological hormone as gibberellic [6, 17]. However, these methods require high technology, costly investment or not achieving the desired effects.

Electrochemical activated (EA) water is a technology developed in the 20th century that interested many researchers in Japan and other countries around the world because of their environmentally friendly solutions [8, 19, 20, 23] to improve product quality, positive effects in malt production with low cost of energy [8, 14, 19]. Anolyte water has a pH of 2.5-5.5 and a reduction in oxidation potentials of +450 to +850 which presented bactericidal property [9, 10, 16]. The catholyte solution has a pH of 8.5 to 5.5 and a reduction in oxidation potential of -230 to -870 which stimulates plant growth [7, 8, 21, 22]. The used of EA water in the production of malt from wheat and rice to shorten the production time, and improve the mail quality In Vietnam, the application of EA water in food processing, especially in malt processing has not been reported yet. The objective of this study is to investigate the effects of EAW on moisture and diastase activities during the malt germination of wheat and rice aimed to apply in food technology in Vietnam.

2. Materials and methodes

2.1. Materials

Wheat grain (APW variety imported from Australia) was supplied by JSC Tien Hung (Tien Son, Bac Ninh, Vietnam). Paddy (Khang Dân) was obtained from Vietnam Academy of Agriculture Science. Electochemical Activated (EA) Water device Электроактиватор АП-1 (Moscow, Russia), which

* Corresponding author: Tel.: (+84) 0868978480
Email: hung.nguyenvan@hust.edu.vn

has 2-liter electrolysis chamber was purchased from Moscow, Russia, enables the production of anolyte and catholyte solution with pH and the oxidation-reduction potential in a relatively large range.

2.2. Grains treatment with anolyte water

Wheat and paddy grains were washed and soaked with an anolyte solution for 10 minutes. Control sample was washd and soaked with tap water. After soaking for 10 minutes, the total microorganism was determined by the colony counting method with total Trypton Glucose Agar (TGA) environment [7, 13].

2.3. Soaking grains with catolyte water before germination.

Samples were soaked arcording to water-air permutation soaking method (Филатова Т.В., 1985) as followed: Wheat was washed with catolyte water at 3 different temperatures of 20°C, 25°C, 30°C. seed were soaked in 4 hours, drained within 1 hour and soaked again. During seed soaking, recorded the changes in moisture content of the kernels. After the moisture reached 40-43%, all samples were germinated at 25ºC for every samples after each day of germination. while germination grains are moistened to 44-45% by periodic moist spraying, then diastase power of fresh malt in each sample was determined.

For paddy, prepared similarly 2 samples: one sample soaked in tap water, the other soaked in anolyte water.

2.4. Grains germination

Wheat was germinated at 3 different temperatures 15°C, 20°C, 25°C. At each temperature, the wheat germinated simultaneously in tap water and catolyte solution. For paddy, two samples with tap water and catolyte solution at 25ºC. Diastase power germinated grain was determined every 24 hours [13].

2.5. Proximate analysis: Moisture of grains was determined according to the methods describes in TCVN 9706-2013, protein - TCVN 10791:2015, lipid - TCVN 6555:2011 [14]

2.6. Diastase power was determined according to the method describes by L. T. Mai [13] expressed by Windish- Kolbach unit.

2.7. Germinative energy (TCVN 8548:2011)

Put two filter papers in petri dish, spreaded 100 grains of soaked wheat or paddy, closed and packed with plastic bag and placed in dark chamber at 20ºC. Take sample every day and recorded number of germinated seed [13] germinative energy was calculated as followed:

$$\text{Germinative energy} = \frac{n}{400} \times 100\%$$

where n – number of germinated grains in the 4-petri dish were eliminated during the gemination time.

2.8. Data analysis

All the experiments were at least triple and calculated the mean value. Statistical analysis was carried out by Microsoft Excell 2010.

3. Results and disscution

3.1 Proximate analysis

Moisture, 1000 grain mass and proximate ingredients of wheat and rice kernels were presented in table 1.

Table 1. Chemical and technical properties of wheat and paddy

	Wheat	Paddy
1000 grain mass (g)	13.23	22.56
Moisture (%)	11.25	8,54
Starch (%db)	60.23	63.18
Total protein (%db)	12.45	8.54
Lipid (%db)	1.82	1.64
Cellulose (%db)	2.53	11.57
Germinative energy (%)	97.38	94.76

Note: %db – % on dry basis

Table 1 showed the high contents of starch in paddy (63,18%) and wheat (60,23%). This demonstrated that both wheat and paddy were high quality extracts for the production of malt beverages [1; 4]. Cellulose content of paddy (11.57%db) was much higher than that of wheat (2.53%db), due to the higher ratio of hush in paddy than that in wheat. Thus, wheat grains might absorb water faster than rice grain due to lack of husk during soaking [26]. The high percentages of chaff in paddy may cause unexpected flavors in beverages after processing, and therefore the necessary treatments should be considered to reduce its negative impact on the quality of the product [2]. Both paddy and wheat have high percentage germination (higher than 94%), which are suitable for malt production from these two cereals. Comparing with barley, the germs of wheat and paddy are located on the outside of the seed shell, which will facilitate the separation of the embryos and roots in malt product and reduces the negative effects of embryos on beverage products. However, it should be careful to avoid germ damage which will make it difficult to accumulate enzymes in fresh malt during the early days of germination. [5].

3.2. Effect of anolyte solution on washing step.

The main purpose of the grain washing step is to remove impurities, broken grains, and microorganisms contaminants. Eliminating the micro-organisms in raw material is very important step because the contamination could not be avoided during the followed soaking and germination steps, . The effects of washingthe grains by anolyte solution (pH = 3.5, 10 min) on the reducing of raw material microorganisms was investigated incomparision with using tap water. The results were shown in table 2.

Table 2. Effects of anolyte solution on microorganism after washing step

	Washing with anolyte solution	Washing with tap water
Wheat	2.10^2 CFU/g	$7{,}7.10^8$ CFU/g
Paddy	$1{,}6.10^3$ CFU/g	$8{,}5.10^{10}$ CFU/g

From table 2, it was clearly seen that the anolyte solution has a remarkable effect on the reducing microorganisms in raw materials. When washing wheat with the anolyte solution, the total microorganism decreased 6 logs (2.10^2 CFU / g) compared with by tap water ($7{,}7.10^8$ CFU/g). For paddy the results were similar, the amount of microorganism in paddy washed by anolyte solution was $1.6\ .10^3$ lower than by tap water ($8{,}5.10^{10}$ CFU/g). The reduction of microorganism caused by the low pH (3.5), and high oxidation reduction potential of 270-300 mV of anolyte solution. Several researchers have been reported that anolyte solution showed the antibacterial activities for both aerobic and anaerobic bacterials [8; 9; 10; 11; 12]. The results in this study also indicated that anolyte solution should be used for washing the grains before soaking in malt processing.

3.3. Effect of catolyte solution on soaking step

- Soaking wheat grain

Wheat grain were soaked in catolyte solution at 3 different temperatures of 20°C, 25°C, 30°C, control sample was soaked in tap water at same temperature. The effect of catolyte solution on grain moisture during soaking was presented in fig.1.

Fig.1 showed that the higher temperatures the wheat was soaked, the shorter time of moisture saturation was reached. At all three temperatures (20, 25, 30°C), the moisture of the grains soaked in catolyte solution was 0.5 - 1% higher than that in tap water becasue the catolyte solution could speed up the moisture absorption rate of the grain [7]

When the seeds reached a moisture content of 40-43%, grains were germinated at 25°C for 3 days, the effect of catolyte solution on enzyme accumulation was evaluated by determining enzyme diastase activity of germination grain on third germination day [13]. The result were presented in fig.2.

It was indicated from fig. 2 that soaking grains at 25°C gave the highest diastase activity in germinated seeds. This could be predicted that this soaking temperature (25°C) facilitated the biochemical and physiological processes in wheat grains [8, 15].

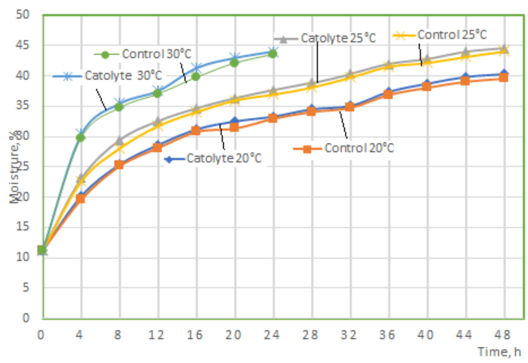

Fig.1. Effect of catolyte solution on wheat moisture during soaking.

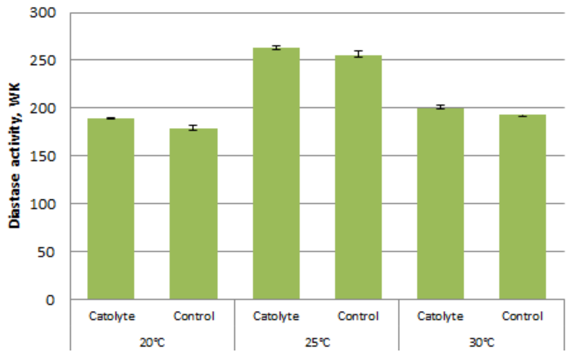

Fig.2. Effects of catolyte solution on diastase activities in wheat grains at different soaking temperature.

Fig. 2 also showed that at the same soaking temperature, wheat soaked with catolyte solution gave higher diastase activity than that with tap water about 5-10%. Thus, it indicated that soaking grains with catolyte solution increased the water absorption speed, and the diastase activity also increased, and soaking grains at 25°C gave the highest diastase activity. Therefore, the grains will be soaked in 25 °C in 40h to 40% moisture for subsequent studies.

- *Soaking paddy*

The effect of catolyte solution on paddy germination was carried out as followed: paddy was soaked in catolyte solution at 25 °C at different temperature to determine the soaking time, then soaked grains were germinated at 25°C in 3 days and diastase activity was recorded [6,7]. Results were showed in fig.3.

The tendency of the grain moisture content changes when soaked in catolyte water and tap water is similar in wheat grain. When the immersion temperature is increased, the immersion time is shortened (Fig. 3). Grain soaked in catolyte water at the same temperature has a 0.5-1% faster absorption rate than the control sample. It was also seen that the rate of water absorption speed of paddy was lower than that of wheat (Fig 3, 4) due to the different in husk structure of paddy grain. The time of soaking paddy at 20°C was 48h, 25°C was 34h and 30°C was 18h. Soaked samples were germinated at 25°C for 3 days, the diastase activities of the grains were presented in fig. 4.

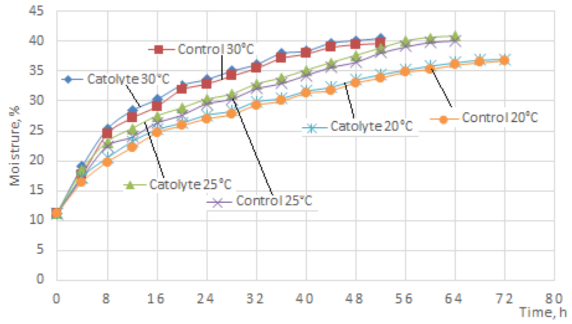

Fig.3. Effect of catolyte solution on paddy moisture during soaking

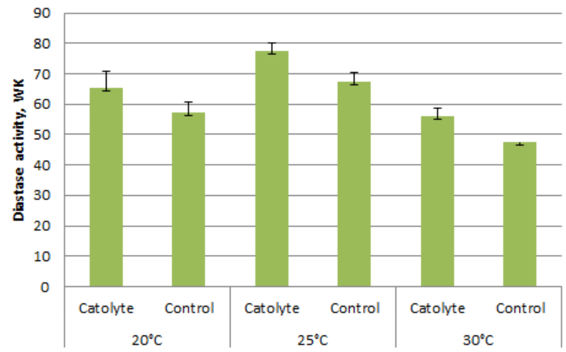

Fig 4. Effect of catolyte solution on diastase activities in paddy grain at different soaking temperature.

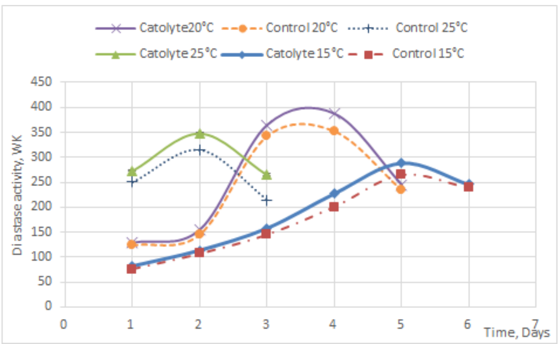

Fig. 5. Effect of germinating temperature on diastase activities of catolyte solution- soaked wheat grain.

From fig. 4, it was found that the soaking temperature affected to the diastase activity in malt. Soaking grains at 25°C gave the highest diastase activity. Fig.4 also showed that at the same temperature of soaking paddy grains with catolyte solution, the diastase activity was always higher than that of tap water. Thus, soaking with catolyte solution increased the speed of water absorption, and the diastase activity after germination would increased.

Especially, soaking seed at 25°C gave the highest diastase activity. From those results, soaking paddy at 25°C in 56 hours in catolyte solution was the best to reach the moisture content of 40%. Фараджева Е. Д. 2001, Филатова Т.В. 1985 found that using catolyte solution could accelerate soaking step of barley and reduce soaking time to 24% [6; 7].

From above results, wheat should be soaked in catolyte solution at 25°C to reach moisture of 40-43%, the diastase activity was highest and anolyte treated paddy was soaked in catolyte solution at 25°C for 56 hours for further study.

3.4. Effect of germination step on germinated wheat and paddy properties.

- *Germination of wheat*

Catolyte solution-soaked wheat was germinated at 3 different temperature and diastase activity was determined every 24 hours. Results were shown in fig.5

Fig. 5 showed that the germinating temperature has a significant effect on the diastase activity in germinated wheat (fresh malt). The germination at higher temperature leaded to the increase in the germination rate but it also caused the development of microorganism in germs [7, 17]. Moreover, if the germinating temperature were low, the time for diastase activity to reach maximum value would be longer and the maximal value would be lower than the germinating at other temperatures. In addition, fig. 5 also showed the effect of catolyte solution, the diastase activity of the catolyte solution soaking samples was significantly higher than that of the tap water soaking sample of 5-10%. The results was in accordance with research of Филатова Т.В. [7] when applying catolyte solution to germinated barley which increased alpha-amylase activity from 25,0% to 33,5%.

As such, wheat grains used the catolyte solution for the highest diastase enzyme activity when incubated at 20 °C.

- *Germination of paddy*

Catolyte solution- soaked paddy was germinated with catolyte solution and control sample was germinated in tap water at 25°C, diastase activity was determined every 24 hours and results were presented in fig.6.

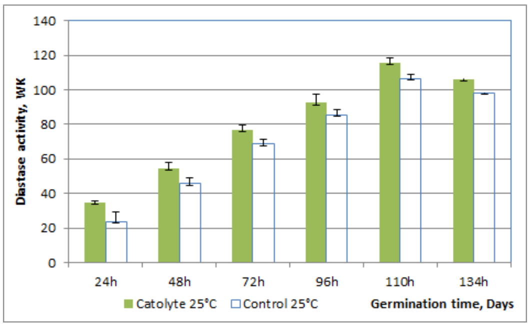

Fig. 6. Effect of germinating time on diastase activity when germinating with catolyte solution.

From fig.6, it was clearly seen that diastase activity changed during germination of paddy grain. Diastase activity increased gradually from the the beginning of germination step to 110 hours, then reduced. Dziedzoave et al in 2010 [3] also found that alpha-amylase activity of paddy reached highest value from 9th to 13th day of germination. Diastase activity of paddy soaking and germinating with catolyte solution was higher than that in tap water (Fig.6). Using catolyte solution to soak and germinated cereals significantly shortened germinating time. The germinated paddy reached maximum activity after germinating at 25°C in 110 hours.

4. Conclusion

The anolyte solution with pH 2.5-4.0 effectively reduce the microorganism contaminants to 5log - 6log in wheat and paddy grains in washing steps. Catolyte solution of pH 8.5-10.5 is the most suitable conditions for soaking and germinating of wheat and paddy, it increased diastase activities to 5 - 10%.

The recommend conditions for producing germinated wheat and paddy as followed: 1. From wheat: wheat was washed in anolyte solution pH 2.5-4.0, then soaked in catolyte solution at 25°C to reach moisture of 40-43% and germinated at 20°C/ 96-104h, the diastase activity was highest. 2. From paddy. Paddy was washed in anolyte solution, soaked in catolyte solution at 25°C, then germinated at 25°C/ 130h in catolyte solution.

Acknowledgments

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