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Full Length Research Paper

Physico-chemical changes and diastatic activity associated with germinating paddy rice (PSB.Rc 34)

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Paddy rice was germinated for 0, 5, 7 and 9 days period at 32°C. Physical and chemical characteristics, as well as diastatic activity were determined using standard methods. Drastic decreases in thousand-grain weight, starch content, and viscosity of malt paste with significant increases in sugar content and diastatic activity were observed during germination (P<0.05). The 9-day malted rice had a diastatic activity of 94.5-degree Lintner, with shorter starch conversion time. The paddy rice studied was therefore suitable for germination and use as an alternate source of enzymes for starch hydrolysis.

Key words: Physico-chemical, diastatic activity, germination, malted rice.

INTRODUCTION

Malting of cereals other than hulled barley has been in research domain in recent years (Dewar et al., 1997; Suhasini and Malleshi, 1995; Hammond and Ayernor, 2001). The reasons being economic considerations and local availabilities. In Ghana, various cereals such as maize, sorghum, rice and millet have been malted for use as sources of enzymes in sugar and brewing industries. Research has shown that malted rice has the potential for achieving high starch conversion rate in sugar production (Hammond and Ayernor, 2000). Malting is a process involving germination and drying of cereal seeds, the prime objective being to promote the development of hydrolytic enzymes that are not active in raw seeds (Dewar et al., 1997). During malting, the seeds undergo various changes of modification such as increase in the quantities of α and β amylases present in the grain and partial degradation (hydrolysis, catalysed by enzymes) of reserve substances (cell wall, gums, protein, starch) in the starchy endosperm (Dewar et al., 1997).

Malted rice is, however less commonly used in brewing than the ordinary raw rice. Whereas barley, wheat and rye produce relatively large amounts of both α- and β-amylases during malting, rice essentially produces α-amylase during this process (Egwim and Oloyede, 2006). Since the combination of both amylolytic enzymes results in a more rapid and complete degradation of starch to fermentable sugars, malts from other cereals are preferred materials for most users. The important role of α- amylase in rice seeds stays in the hydrolytic breakdown of reserve starch in endosperm tissues during germination. Since barley, wheat and rye are not usually grown in Ghana, there is a need to explore other locally grown cereals especially rice for the production of malt for local sugar and brewing industries. However the quality of malt for use is greatly influenced by the physical, chemical and enzymes activities within the seeds and those that are produced during germination.

The purpose of this contribution is to investigate physicochemical changes and diastatic activity associated with germinating of local paddy rice as a source of enzymes in starch conversion and brewing industries.

MATERIALS AND METHODS

Paddy rice (PSB. Rc. 34) was purchased from the Irrigation Development Authority (IDA) at Ashaiman near Accra, Ghana. The seeds were stored dry at 4°C prior to analysis.

Germination process

Viable seed were used for the germination process. About 300 g of paddy rice was cleaned, washed thoroughly in water and soaked in a volume of water 3 times the weight of seeds for 24 h. The soaked seeds were placed on a jute sack in a basket and kept under ambient temperature (25 – 35°C) and watered 2 – 3 times a day to en

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Table 1. Properties of paddy rice and malt.

Property	Paddy rice (0 day malting)	5-days malting	7-days malting	9-days malting	$LSD_{0.05}$
Moisture (%)	11.92 ± 0.14	9.06 ± 0.16	13.51 ± 0.10	12.51 ± 0.06	-
Reducing (%)	3.26 ± 0.01[a]	6.72 ± 0.06[b]	12.20 ± 0.08[c]	12.44 ± 0.00[d]	0.025
Non-reducing (%)	0.30 ± 0.05[a]	1.24 ± 0.01[b]	3.56 ± 0.01[c]	3.92 ± 0.06[d]	0.03
Diastatic power (°L)	0.00 ± 0.00[a]	52.20 ± 0.00[b]	72.00 ± 1.27[c]	94.50 ± 1.27[d]	2.33

Values are averages of triplicate ± standard deviation on dry matter basis. a-d = Values with different letters in the row are significantly different at P<0.05

Table 2. Correlation between starch content and some malt characteristics of paddy rice.

Malt Characteristics	Starch Content
Thousand-grain weight	+ 0.99*
Viscosity at 75°C	+ 0.98*
Viscosity at 36°C	+ 0.97*
Diastatic power of malt	- 0.99*

Significant at P< 0.05. F.C.K. OCLOO.

hance germination process. Samples were taken for days 0, 5, 7 and 9 for analysis.

Sample preparation for analysis

Samples taken for days 0, 5, 7 and 9 were solar dried (38°C) for about 20 – 25 h. The dried malt samples were milled using a disc attrition mill (Straub model 4E Grinding mill, Straub Co PHILA, USA). The milled rice malt samples were packaged and stored at cold room temperature (4°C).

Physical and chemical analysis

Samples were analyzed for moisture using AOAC method (AOACN°925.10, 1990). Starch, reducing and non-reducing sugars were determined using AOAC (AOACN°923.09 and 930.45, 1990) methods. Starch conversion time was determined using the method described by Cecil (1995). A drop of mash prepared from the samples was stirred with iodine solution in test tubes and time taken for the blue-black colour to disappear recorded.

Thousand-grain weight determination

Hundred (100) grains of paddy rice malted at 0, 5, 7 and 9 days rice were randomly selected from the bulk and weighed using balance. Each weight was multiplied by 10 to obtain the 1000 kernel weight (Esiape, 1994). Determinations were done in triplicate.

Malt yields and malting loss

Malt yield after each germination was determined by weighing the seeds with plumule after malting. The weights of 50 grains were recorded before malting, after malting and drying the radicle (roots) were removed by hand and the yield of the malt determined by weighing. Malt yields were expressed as percentage on dry matter basis.

Malting loss after each germination period was determined by weighing the rice seeds before and after malting. The weights of 50 grains were recorded before malting, after malting and drying the plumule and the radicle (roots) were removed by hand and weight of malted seeds recorded. Malting losses were expressed as percentage on dry matter basis.

Viscosity determination

The viscosity of the pastes of rice malts was determined using Brookfield Viscometer (Model DV - + IV Viscometer Version 4.1, Brookfield Engineering Labs Inc., Stoughton, USA). Ten grams of sample was dissolved in 500 ml distilled water (2% slurry). The suspension was heated on a water bath with constant stirring for 30 min at a temperature of 90°C. The viscosity of the resulting gelatinized material was determined at 75 and 36°C at 50 rpm using spindle number 1.

Determination of diastatic activity

The diastatic activity was determined using Association of America Cereal Chemists Method 22-15 (AACC, 2003).

Statistical analysis

ANOVA and regression analyses were performed on the data using Statgraphics Computer Software (Statistical Graphics Corp., STST Inc; USA) with probability, $P < 0.05$. Significant means were separated using Least Significant Difference ($LSD_{0.05}$).

RESULTS

Moisture

Table 1 shows chemical and physical properties of paddy rice and malt. Moisture content varied from 9.06 to 13.51 %. However, these moisture contents depended upon the duration of drying and the temperature.

Malt yields and malting loss

The yield and loss of malted paddy rice grains are presented in Figure 1. There were marked differences in the malting loss and malt yield of the grains during germination. Malting loss was highest in 9-day malt (about 59.75%). The malting loss for 5-day malt was lower than in 7-day malt, recording 16.8% as compared to 25.90% respectively. Malt yield was invariably higher (92.81%) when germination was for 5-days.

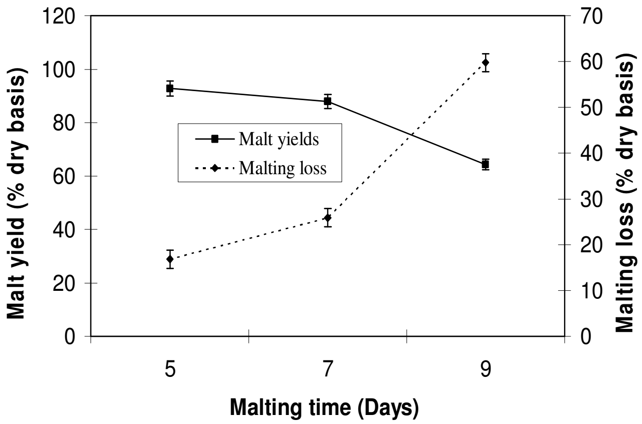

Figure 1. Yield and loss of malted paddy rice grains.

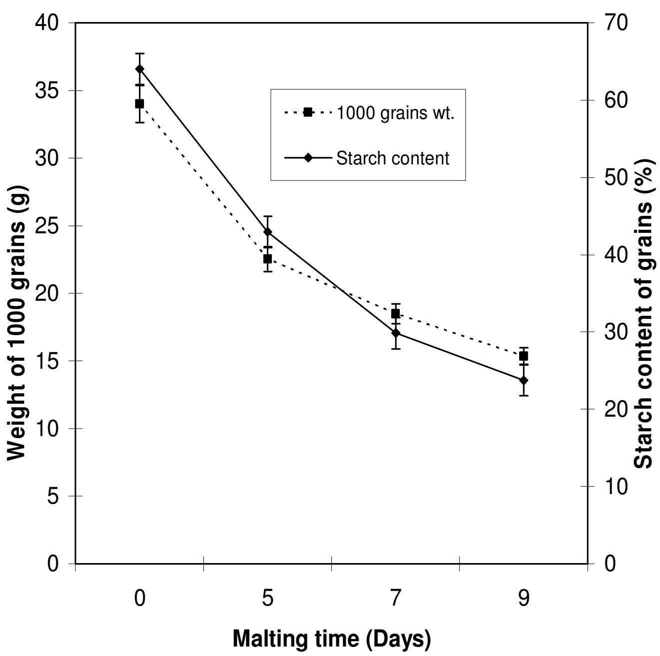

Figure 2. Effect of malting on the weight and starch content of paddy rice grains.

Thousand-grain weight and starch content

Figure 2 shows the effect of malting on the weight and the starch content of paddy rice grains. Drastic changes in the thousand grains weight and the starch content of the paddy rice grains were observed during germination. Thousand grains weight decreased from 34.00 to 15.36%, about 54.8% of weight loss. The starch content also decreased from 64.03 to 23.74%. The starch content for the 9 day malt was 37% of the original starch content of the paddy rice. Germination significantly ($P<0.05$) affected both thousand grains weight and the starch content of the paddy rice grains. Regression analysis of the

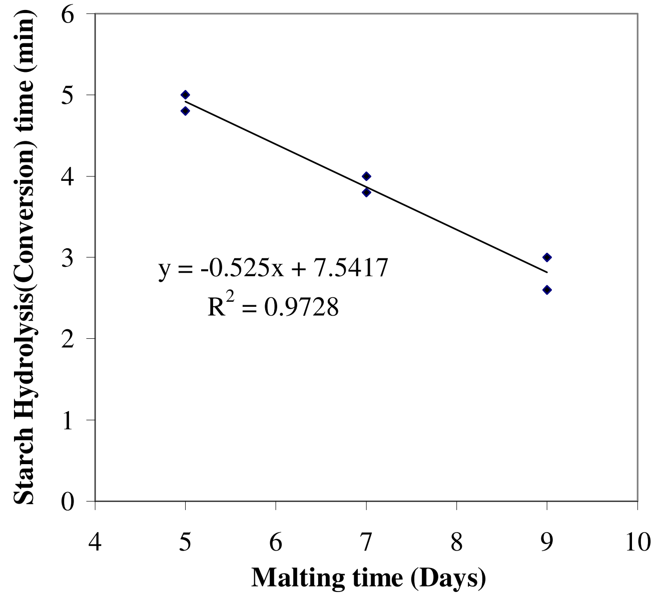

Figure 3. Effect of malting on the starch conversion / saccharification time of rice malt.

data obtained showed that thousand grains weight significantly correlated with starch content of the grain (r = + 0.99, $P<0.05$) (Table 2).

Reducing and non-reducing sugars

The main sugar of rice embryo and endosperm is glucose, together with small amounts of raffinose, and fructose. Reducing and non-reducing sugars also increased significantly ($P<0.05$) during germination (Table 1).

Saccharification / starch conversion time

Starch conversion time is the time taken to convert starch into sugars. Saccharification time decreased with increasing malting time (Figure 3). It decreased from the average values of 4.9 to 2.8 min. Regression analysis of the conversion time data produced the following linear regression model equation:

$$Y = -0.525x + 7.5417$$

Where Y = conversion time and x = malting time.

The correlation coefficient (r) of this expression was 0.986 and the coefficient of determination (R^2) was 97.28 %. The model indicated significant ($P<0.05$) effect.

Viscosity of pastes of rice malt

Figure 4 shows the effect of germination on viscosity of malt paste at temperatures of 75 and 36°C. At both tem-

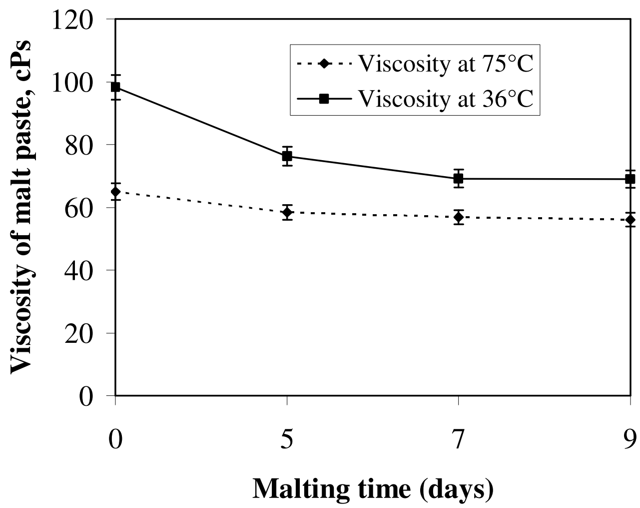

Figure 4. Effect of germination on viscosity (cps) of malt paste at temperatures 75 and 36 °C.

peratures, viscosity decreased during malting. Regression analysis of the data showed that viscosity at both 75 and 36°C correlated with starch content of the grain (r = + 0.98 and r = + 0.97 respectively, P<0.05) (Table 2).

Diastatic activity of malted rice

The amylolytic activity of the paddy rice malt increased with germination. The diastatic activity increased signify-cantly (P<0.05) during germination from 0.00 to 94.50°L (Table 1). Regression analysis of the data showed that diastatic activity correlated with starch content of the grain during malting (r = - 0.99, P<0.05) (Table 2).

DISCUSSION

The values obtained for moisture are generally low and therefore may enhance shelf-life of the malt samples produced. Moisture content gives an index of quality and consistency of the milled grains. Moisture content of grains would be low if high temperature is used and also when the time of drying is extended for medium temperature drying. It is important to dry the malt to a slightly lower moisture level if one intends to store the malt for any considerable length of time.

Malting loss is the material lost, as per cent dry weight in converting the grain into malt. The results obtained suggest that as the malting loss increases with increasing duration of germination, the malt yield decreases. Suhasini and Malleshi (1995) reported that malting loss was caused by metabolic activity and separation of vegetative growth (root and shoot) and increased with the increase in duration of germination. Similar trends were also reported by Hammond (2001). These observations could be attributed to the chemical changes that occurred during the malting process (Table 1). The partial degradation of high molecular weight materials in the starchy endosperm of the paddy rice during malting resulted in the observed increases in malting loss and decrease in malt yields.

The thousand grains weight of cereals is also used to determine the suitability of grains for malting. It also reflects the density and the seed size of the commodity. Starch serves as carbohydrate source, which provides energy to the seed during germination. There were general decreases in the thousand grains weight and starch content of the paddy rice grains. Since there was a positive correlation, whenever there was a reduction in starch content of the paddy rice grains during germina-tion, there would be equivalent reduction in the thousand grains weight. Similar changes were observed by Suhasini and Malleshi, (1995). The decrease in the thou-sand grains weight observed could be attributed to the physiological activities. During germination, physiological activeties in the grains increased due to the action of enzymes leading to the utilization of food reserves for energy and growth. Also, the duration of malting resulted in losses in grain constituents. Furthermore, leaching of minerals and other grain constituents during steeping and germination might in part have accounted for the reduction in the thousand grains weight.

The decrease in the starch content of the grains during germination was also due to the action of hydrolytic enzymes such as α- and β- amylases, which hydrolyze starch into low molecular weight carbohydrates such as maltose, glucose and dextrins. Such gradual decrease in starch during germination is well known. The longer the duration of malting, the smaller the residual starch and consequently higher simple sugars. High starch content tends to be associated with large grain size. The breakdown in the starch content of the paddy rice germinated for 0, 5, 7 and 9 days might have contributed to the observed increase in malting loses and decrease in malt yield (Figure 1), as well as the observed sugar values. A considerable increase in the sugar contents in both embryo and endosperm was detected in early germinating Sorghum (Gill et al., 2003).

The starch conversion time of 5- day malt was longer than that of 7 and 9-day malts, possibly due to the lower amylolytic activity of the 5-day malt. Since the model obtained had a significant effect, the equation arrived at could be used to predict the conversion time for paddy rice malt for a particular malting time. The R^2 observed showed that about 97% of the variability of conversion time (*Y*) could be attributed to differences in malting time (*x*).

Viscosity determination of malt paste is important because it is one of the physicochemical attributes of malt content in hydrolytic enzymes. The results obtained were predicted because the decrease in starch content would result in less gelatinisation occurring and hence decrease in the viscosity of the paddy rice grains.

The decrease in the viscosity of the malt paste was due to the action on the starch by hydrolysing enzymes that were produced during malting. Starch breakdown proceeds by the combined actions of α-amylase, debranching enzyme (pullulanase like enzyme), β-amylase and α-glucosidase in germinated cereal seeds (Zeeman et al., 2007). Sumathi et al. (1995) reported lower viscosities in malted legumes with corresponding increased in amylase activity.

Diastatic power/activity gives a measure of the saccharifying power of the malt prepared. It was originally considered to give a relative measure of starch-converting power of malt. This is however partly true as the α-and β-amylases, which together constitute "diastase" and other enzymes such as amyloglucosidase and iso-amylase may be present in malt and are differentially affected by heat. Liquefying and dextrinising power are associated mainly with α-amylase activity and saccharifying power mainly with β- amylase activity. The trend observed corresponded positively with that reported by Hammond (2001).

Conclusion

The 9-day malt of high diastatic activity had the highest rate of starch conversion as compared to 0, 5 and 7 days malting. There were decreases in starch content and viscosity of malt paste, which was accompanied by increase in reducing sugar content and diastatic activity of malt ($p<0.05$) during malting. Starch conversion time of the rice malt decreased with increasing germination time. The physical and chemical changes observed were as a result of increase in the activity of hydrolytic enzymes present in the grain. The paddy rice studied was suitable for germination. However further studies need to be conducted on other varieties of rice available in the country for their malting characteristic

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