

## STEEPING: A WAY OF IMPROVING THE MALTING OF RICE GRAIN

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### ABSTRACT

*Water availability significantly affects the mechanism through which grain is converted into malt. High moisture content enhances enzyme production and shoot emergence. To examine this effect on rice malt, rice grains were soaked for different periods with the aim of establishing the optimum that significantly affects the final malt quality. The out-of-steep moisture content (SMC), steeping loss, germination energy, shoot length and the diastatic activity of the malt were evaluated.*

*Statistical Analysis indicated that steeping period correlates positively with rate of water uptake ( $r = +0.84$ ) and steeping losses ( $r = +0.97$ ). Germination energy was dependent on steeping period with 48-h (35% SMC) and 72-h treatment (36% SMC) recording the highest energies of 91 and 96%, respectively. 48-h steep grains produced the highest mean shoot length of 4.34 cm and diastatic activity (667.81 U/g). Soaking rice grains for 48 h during malting significantly improves its total hydrolytic power to ensure higher convention of starches into fermentable sugars.*

### PRACTICAL APPLICATIONS

*Malting of cereal grains other than barley has attracted a lot of attention in recent years. The reason has been the need to find suitable alternative to imported barley. Improving the malting qualities of rice malt will thus enhance its potential and usage in brewing and sugar syrup industries especially in the*

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*tropics. This current finding reveals that soaking rice grains for 48 h facilitate water uptake, which is essential for maximum production of diastase required for higher conversion of starch into simple sugars. Brewing and other related industries can therefore make use of rice malt in many product developments. In this regard, value will be added to local rice and other cereals thereby creating ready market and improving the country's economy at large.*

## INTRODUCTION

Malting is the limited germination of cereal grains or, occasionally, the seeds of pulses (peas and beans), under controlled conditions with the primary objective of promoting the development of hydrolytic enzymes (Briggs 1998; Ayernor and Ocloo 2007). Malt prepared from barley is by far the most important. However, malt from other cereals including rice has attracted a lot of attention in recent years because of economic considerations and local availability (Hammond and Ayernor 2001; Agbale *et al.* 2007). The search for these alternative sources has also been fueled by the quest to add value to local raw materials, create ready market for farmers while boosting the agricultural sector and the country's economy at large (Dziedzoave *et al.* 2005). Maize malt has been successfully used in preparing maltose syrup in Vietman (Cecil 1995) whereas sorghum malt is commercially used in Southern Africa and Nigeria as source of amylases in brewing (Dewar *et al.* 1997). In Ghana, rice malt is used to convert cassava flour into glucose syrup (Dziedzoave *et al.* 2005). Research conducted by Hammond and Ayernor (2000) reveals that malted rice has a higher potential for converting starchy materials into glucose syrup as compared with millet, sorghum and maize. Agbale *et al.* (2007) evaluated the malting properties of some tropical cereals and confirm this early assertion about the hydrolytic potential of rice malt. Nevertheless, the diastatic power of rice malt (129°Wk) was far less compared with barley (340°Wk). There is therefore the need to conduct further studies on the malting procedures to establish optimum conditions necessary to enhance the hydrolytic power of rice malt. Optimizing the diastatic power of rice malt would make it a suitable substitute for barley. Among conditions that are known to enhance enzymes production during malting is steeping. Steeping, which is the soaking of grains in water, is widely acknowledge as the most critical stage in malting (Dewar *et al.* 1997). It is the stage at which grains absorb water to restores their metabolic activity that leads to extensive physiological and biochemical changes including production of hydrolytic enzymes and development of the embryo (germination). Enzymes production in grains is thus significantly affected by the steeping period (Dewar *et al.* 1997; Basra *et al.* 2006). This

study was therefore conducted to establish the optimum steeping period that improves the hydrolytic potential of rice malt for brewing and sugar syrup production.

## MATERIALS AND METHODS

Jasmine 85 rice grains, stored for 10 months, were obtained from Crop Research Institute (CRI), Kumasi, Ghana. The randomized complete block design with three replicate was used for all the experimental runs.

### Steeping of Rice Grains

Three replicates of 50 (1.5 g) Jasmine 85 rice grains were soaked in 200 mL distilled water for 12, 24, 36, 48, and 72 h at a temperature of  $28 \pm 1$  C. The steeping was carried out in a micro malting chamber, and the steep liquor was changed every 12 h. Out-of-steep moisture contents (SMCs) and malting (steeping) losses were determined at the end of the steeping periods. Weight gain, germination energy, shoot lengths and the diastatic power of the soaked grains were also determined.

### Out-of-SMC Determination

The moisture content of the soaked rice grains were determined at out-of-steep using the Association of Official Analytical Chemists (AOAC 1990) approved method.

### Steeping Loss and Weight Gain Evaluation

Percentage dry weight losses of the soaked grains were determined by taking the dry weight of the grains before and after soaking using a laboratory electronic balance (Adventurer Pro AV264, Greifensee, Switzerland) (Wijngaard *et al.* 2005).

### Germination Energy Determination

Three replicates of 50 rice grains were soaked in distilled water for the different steeping periods and germinated in the malting chamber. The grains were placed in Petri dishes lined with two Whatman's filter papers. About 8 mL of distilled water was sprayed on the grains daily. To assess the rate of germination of the grains, emergence counts were made over 24 and 48 h. The ratio of germinated grains to the total grains was calculated and recorded as the germination energy of the grain (Hammond and Ayernor 2001).

### **Shoot Length Determination**

The shoot lengths of 10 seedlings per replicate for each treatment (steeping periods) were measured using a measuring ruler. The means were calculated and recorded as the average lengths.

### **Malting Loss of Rice Seedlings**

The malting loss at different germination intervals was determined using the methods describe by Ayernor and Ocloo (2007).

### **Kilning of Rice Seeds**

Drying of soaked, and green malts were carried out in a forced air conventional oven at 40–45C for 5 h.

### **Extraction of Enzymes from Rice Malt**

Method described by Osman (2002), and Ayernor *et al.* (2002) was employed. Some modifications were however, made. Na-phosphate (pH 8) was used and the final extract was diluted by a factor of 50 using 0.1 M malate buffer (pH 5.5). Rice malt extracts were made from both the soaked rice grains and the germinated grains under the different steeping treatments.

### **Diastatic Activity Determination**

The total starch degrading enzymes (diastase) in the soaked grains were assayed using 3,5-dinitrosalicylic acid method for reducing sugars (Canizares-Macias *et al.* 2001; Osman 2002). A unit (U) of diastase was defined as the amount of enzymes required to release reducing sugars equivalent to 1  $\mu\text{mol}$  of maltose/min under the stated conditions. Alternatively, enzymatic activity was expressed in maltose equivalent as grams per 100 g dry malt per 10 min (g/100 g dry malt/10 min), similar to Windisch-koldach units.

### **Statistical Analysis**

Data obtained were subjected to statistical analysis to determine significant differences or otherwise between the treatment means at  $P = 0.05$  using Microsoft Excel Program.

## **RESULTS AND DISCUSSION**

### **Water Uptake Rate of Rice Grains**

The water uptake rate of Jasmine 85 rice grains during 72-h steeping period is presented in Fig. 1. Generally, the rate increased with increasing

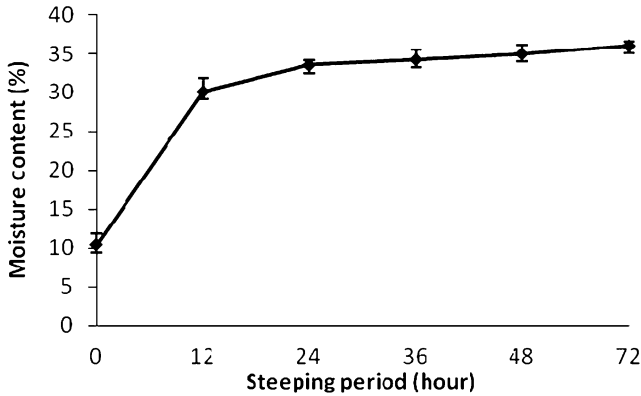


FIG. 1. WATER UPTAKE RATE OF SOAKED RICE GRAINS

steeping period with a positive correlation ( $r = +0.84$ ,  $P < 0.05$ ). The rate was very rapid in the initial stages, from 10.46 to 30% (by 20%), after 12 h of steeping. Thereafter, it slowed down gradually and became fairly constant (plateau) until the 48 h where it rose slightly to reach a final out-of-SMC of 36%.

In general, when grain is soaked in water, the moisture content increases rapidly during the initial stages but progressively slows down (Wijngaard *et al.* 2005). Barley grain reached a moisture content of 24% after the first phase of water uptake whereas the water uptake rate was extremely rapid in buckwheat after the first 13 h of steeping (Wijngaard *et al.* 2005). This sharp increase could be attributed to the fact that water potential of soaked grains are usually lower than that of the steeped liquor. Hence water moves from the outside (steeped liquor) into the grain. The flow continues until the magnitude of the water potential gradient tends to a limited value (equilibrium) (Salisbury and Ross 1992). The driving force behind the water movement could also be attributed to the high osmotic gradient generated by simple sugars present mainly in the embryo of the grain.

Briggs (1998) also observed a similar trend in other cereal grains and concluded that the rate of water absorption declines gradually after the initial stage until a condition that the grains chit (start to germinate). In this current study, the grains chitted after 48 h of steeping, and the absorption rate consequently increased slightly after the plateau stage. Chitted grains tend to take up moisture more rapidly than those which have not during steeping (Briggs 1998). To ensure adequate moisture uptake rice grains should be soaked for longer periods.

### Steeping Losses of Grains

The relationship between steeping period and malting (steeping) losses of rice grains is presented in Fig. 2. Increasing steeping period directly increases steeping losses ( $r = 0.97$ ,  $P > 0.05$ ). Steeping losses recorded under this study fall between 0.12 and 1.42% of the initial dry weigh. These losses resulted from dissolution of materials from the soaked grains by leaching, and metabolic activity releasing  $\text{CO}_2$  and ethanol (Wijngaard *et al.* 2005). Displacement of dust and spent (damage or partially filled) grains could also be a contributing factor.

To minimize steeping losses, the rice grains were sorted out and the spent grains skimmed off prior to steeping. Hence the smaller losses recorded as compared with values obtained in other investigations (Wijngaard *et al.* 2005). Dissolved materials that have been identified to leach out of the grains into steep liquor include uncharacterized pigments, and mineral salt such as phosphates (Briggs 1998). It has been reported that about 10% of grain's phosphate can leached out if the grain is soaked for a longer period (Briggs 1998). Bam *et al.* (2006) reported that phosphate is among the essential constituents of metabolic enzymes that catalyses germination processes and also influences early seedling growth. Therefore leaching of such materials could affect enzyme production and the final quality of rice malt. The positive correlation recorded between steeping period and loss implies that the longer the steeping period, the higher the losses. The optimum steeping period of rice grain should thus be a balance between steeping duration and losses.

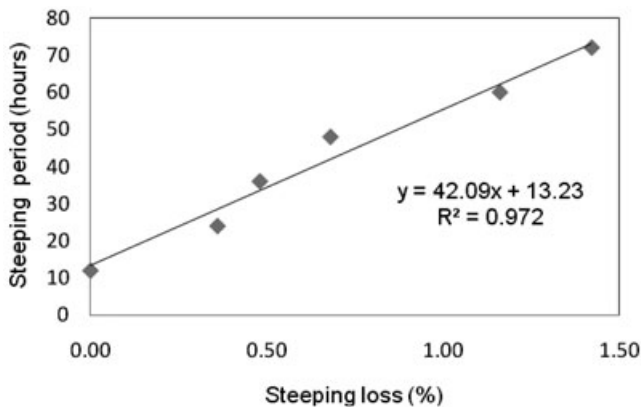


FIG. 2. CORRELATION BETWEEN STEEPING PERIOD AND LOSSES OF SOAKED RICE GRAINS

### Germination Energy of Rice Grains

Figure 3 shows the germination energy of soaked rice grains over 24 and 48 h of germination. The germination rate increased as the steeping period was extended. This trend was confirmed when the results were subjected to statistical analysis, which indicated a positive correlation between the steeping time and germination energy ( $r = +0.87$ ,  $P < 0.05$ ). During the 24-h germination period, 49.3% of the 24-h steep grains germinated whereas none germinated under the 12-h steeping period. However, 84.7, 90.6 and 96% of the grains soaked for 36, 48, and 72 h, respectively, had germinated. Germination was observed in the second day for the 12-h steep grains with a germination energy of 70% whereas it increased to 94% in the 24-h steep grains with 36, 48 and 72-h steep grains obtaining 96%, 96.6% and 98.70%, respectively.

The differences in the germination energies were mainly caused by the variations in the rate of water imbibitions during the steeping process (Fig. 1). Higher SMC enhances seed vigour and enzyme activities (Agbale *et al.* 2007). Grains soaked for 36, 48 and 72 h absorbed a significant amount of moisture that triggered the early development of the embryo. Bam *et al.* (2006) observed a similar germination pattern in IDSA rice seeds. Hammond and Ayernor (2001) recorded germination energy of 88% in the 2<sup>nd</sup> day after steeping PSB.RC 14 Rio Grand rice seeds for 24 h. In malting, more than 90% of the grain must germinate promptly if good quality malt is to be obtained (Dufuor 1994; Agbale *et al.* 2007). Briggs (1998) reported that hydration of grains must meet the water requirement of the aleurone layer, both for enzyme production and for migration of enzymes through the multicellular complex of the endosperm. Hence to germinate rice grains promptly, the hydration period should be extended to a level that would enhance adequate water uptake while minimizing losses.

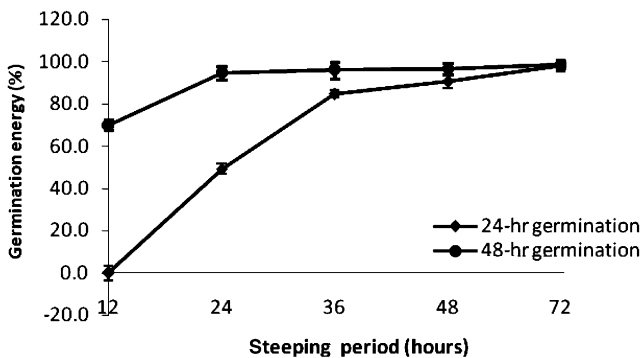


FIG. 3. GERMINATION RATE OF SOAKED RICE GRAINS

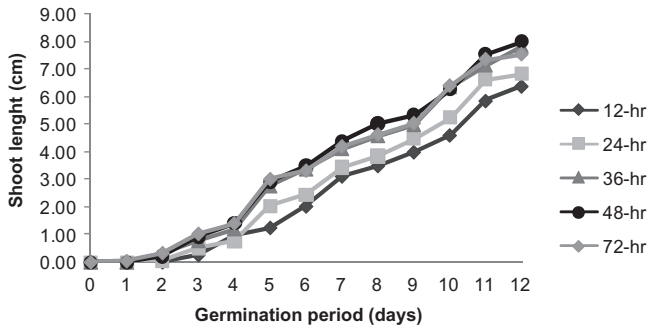


FIG. 4. SHOOT LENGTH DEVELOPMENT OF SOAKED RICE GRAINS

### Shoot Length Development of Rice Grains

Figure 4 shows the development of shoot length against malting period. The shoot lengths of the rice seedlings from all the four steeping periods increased with increasing malting periods. The 48-h steep grains produced shoot with the highest mean length of 4.34 cm followed by 72-h soaked grains of 4.02 cm, and 3.94, 3.26 and 2.81 cm for the 36-, 24- and 12-h steeps, respectively. The differences in shoot length were apparent from the third day after germination. Bam *et al.* (2006) and Wahyuni *et al.* (2003) working on rice seedling establishment observed similar trends. Basra *et al.* (2006) reported higher shoot length for 48-h steep rice grains than the 72- and 12-h steep grains. In general, shoot emergence was improved by soaking rice seeds for a longer period. The differences in the shoot lengths show that steeping period has significant influence on germination and shoot development of rice grains.

Traditionally, the growth of the shoot has been used as a measure of the degree of enzymatic modification during malting (Hammond and Ayernor 2001). Statistical analysis showed a positive correlation ( $r = 0.93$ ,  $P < 0.05$ ) between the shoot length and diastatic power of the rice malt. It could therefore be deduced that the 48-h steep grains that produced the highest mean shoot length would have a higher diastatic activity.

### Malting loss (%) and Moisture Content (%) of Rice Malt

Figure 5 shows the correlation between malting loss and moisture content of rice malt. Both parameters increased with germination time. The highest malting loss and moisture content of 30.1% and 72%, respectively, were recorded in the 12th day. Malting loss increased with increasing germination periods (Hammond and Ayernor 2001).



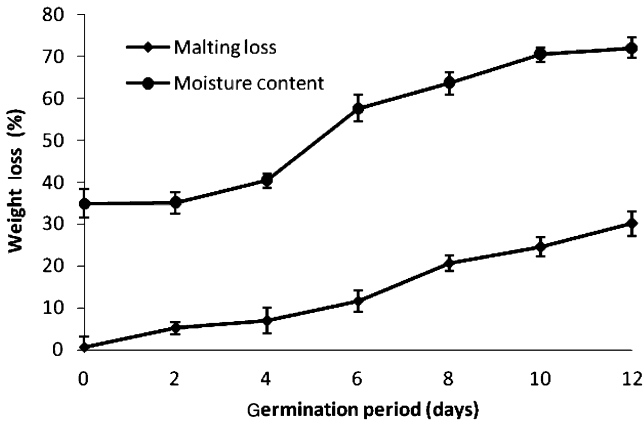


FIG. 5. MALTING LOSS AND MOISTURE CONTENT OF RICE MALT

Malting loss is the material lost in converting grains into malt and is always expressed on dry basis (Ayernor and Ocloo 2007). The losses recorded therefore were mainly caused by the growth and respiratory activities of the grains giving rise to carbon dioxide and water. The intensity of respiration and the subsequent losses varies with germination periods (Briggs 1998). Malting losses result mainly from respiration of grain and fermentative processes (Wijngaard *et al.* 2005).

Statistical analysis indicated a positive correlation between malting loss and moisture content ( $r = +0.96$ ,  $P < 0.05$ ). The increase in moisture content showed that water added to the malting grain was taken up rapidly by the grains. Pelemer *et al.* (2004) reported a similar trend in pearl millet malting.

### Diastatic Activity of Soaked Rice Grains

The diastatic activities of the soaked rice grains are presented in Table 1. The results indicated that steeping period has a significant effect on diastatic activities, generally. Forty eight-hour steep grains had the highest diastatic activity comparatively. Steeping losses resulting from leaching of essential minerals, and metabolic activities could be a major contributing factor for the slight reduction of diastatic activities in the 72-h steep grains. A higher steeping loss was recorded during the 72-h steep (Fig. 2). Phosphate, a major substance that easily leached out into steep liquor, is known to be an important constituent of metabolic enzymes that influences modification and seed vigor (Bam *et al.* 2006). Therefore the leaching of such substance could affect the activity of some enzymes such as phosphorylase, which catalyses the reversible phosphorylation of terminal, non-reducing glucose residues of starch to release glucose 1-phosphate (Briggs 1998).

TABLE 1.  
DIASTATIC ACTIVITY OF SOAKED RICE GRAINS

Steeping period (days)	Diastase activity*	
	U/g dry malt	WK†
0(unsoaked)	502.24 (1.5) <sup>a</sup>	171.77
12	510.52 (1.8) <sup>b</sup>	174.60
24	596.80 (2.0) <sup>c</sup>	203.85
36	604.34 (2.3) <sup>d</sup>	206.68
48	667.81 (1.4) <sup>e</sup>	228.39
72	650.30 (1.6) <sup>f</sup>	222.40

\* Diastase is the collective name for all starch-degrading enzymes.

† WK = diastatic activity expressed in maltose equivalent (g/100 g malt/10/60C).

Standard deviations are presented in parenthesis.

Mean values in each column with the same superscript are not significantly different ( $P = 0.05$ ) based on least significant difference test.

In general, steeping treatment has been reported to increase enzyme activities. Soaking IDSA 85 rice seeds in distilled water for 24 h stimulated the synthesis of more dehydrogenase than the unsoaked (Bam *et al.* 2006). Dewar *et al.* (1997) reported a significant increase in diastatic activity when sorghum grains were hydrated for longer periods (40 h) than the 24 and 16 h. The results obtained imply that hydration (steeping) period has a greater impact on hydrolytic potential of malt.

## CONCLUSION

The optimum steeping period that significantly improves the final quality of rice malt is 48 h. Malts produced under this treatment had the highest diastatic activity to ensure adequate conversion of starches to fermentable sugars. It is therefore recommended that rice grains should be soaked for 48 h in order to obtained high quality rice malt.

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