African Journal of Biotechnology Vol. 7 (23), pp. 4331-4335, 3 December, 2008
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2008 Academic Journals

Full Length Research Paper

Quality assessment and potential utilization of high amylolytic Nigerian maize cultivars

Awoyinka, O. A.[1,3]* and Adebawo, O. O.[2]

[1]Biochemistry unit, Chemical and Environmental Sciences Department, Babcock University Ilisan-Remo, Nigeria.
[2]Biochemistry Department Olabisi Onabanjo University Ago–Iwoye, Nigeria.
[3]Molecular Biophysics unit, India Institute of Science (IISc), Bangalore, India.

Accepted 23 September, 2008

This study was carried out to compare the qualities of two acclaimed Nigerian amylolytic maize cultivars; SPMAT and TZEE*TZEE-W*DEMARSCUS*TZEE-W with barley, red and white sorghum. Results obtained (P ≤ 0.05) showed marked differences in the properties of the two maize cultivars compared to barley, white and red sorghums. Suggestions on the application of these cultivars were discussed based on our findings.

Key words: Amylolytic, cultivars, diastatic power, swelling power, foaming stability.

INTRODUCTION

In January 1988 Nigerian government banned the importation of barley due to the rapidly dwindling foreign reserve of the country (Oyelaran-Oyeyinka, 2002). Following this government policy industry such as the brewing industry and researchers vigorously diverted their research interest in finding substitute for malted barley with little success. Researches and studies carried out by Nigerian scientists showed that sorghum was found to be most suitable for barley replacement especially in brewing (Shambe et al., 1989; Adamson et al., 1999; Oyelaran-Oyeyinka, 2002). The government's bow to pressures to liberalize trade in the year 2000 has resulted in disinterest by most indigenous scientists thereby minimizing works in this field of research of finding an alternative to foreign cereal-barley (Agu, 2002; Egwim and Oloyede, 2006; Adewale et al., 2006).

The ubiquity of cultivated maize compared to other cereals especially in this tropical part of the world and its growing demand for usage as a gluten-free cereal (Sweeny, 2004) in treating celiac disease (Dicke, 1953; Van De Kamer and Weijer, 1955; Papadopoulos, 2001) leave much to be desired as regards its exploitation in food and allied industries. Hence this study was undertaken to explore and compare the various properties of SPMAT and TZEE*TZEE-W*DEMARSCUS*TZEE-W, our acclaimed high amylolytic (rich in both α and β amylases) Nigerian maize cultivars (Awoyinka and Adebawo, 2008). This is in a bid to assess how it can compete with preferred cereals; sorghum and barley in malt production.

MATERIALS AND METHODS

Cultivar collection

Maize cultivars SPMAT and TZEE*TZEE-W*DEMARSCUS*TZEE-W were collected from the International Institute of Tropical Agriculture (IITA) Ibadan. Barley was collected from Nigerian Breweries Plc. Lagos while Sorghum for an onward delivery to Breweries was collected from Talbod Ventures, Lagos.

Diastatic power

The combined effect of α- and β- amylases was determined on the malted grain of the respective cereal based on our previous method of analysis (Awoyinka and Adebawo, 2008).

Malting loss

The grain was malted and the malting loss was calculated using the below equation as suggested by Dewar et al. (1997): Malting loss = [(Initial dry weight of grains – dry weight of malt)/Initial dry weight of grains] x 100%.

*Corresponding author. E-mail: woyinka@yahoo.com, oawoyinka@babcockuni.edu.ng.

Ash composition

The ash content in the sample was determined by incineration with the furnace at 550°C (method 923-03, AOAC, 1990) after a period of 31 - 32 h a white ash was removed and placed in a desiccator for 1 h and then weighed. Ash content (%) = (Weight of Ash/ Weight of sample) x 100%

Protein content

On each of the defatted malted sample, nitrogen was determined by the Kjeldahl method of the Association of Official and Agricultural Chemists (A.O.A.C, 1990). Protein concentrate was first prepared according to Egan et al. (1981). Defatted flour was dispersed in 70% ethanol at a ratio 1:10 (w/v) for 30 min before centrifugation. Protein content was then determined on the precipitate collected.

Fat content

This was carried out according to (AOAC, 1990). Diethyl ether at 50ºC was used for the extraction under reflux for 5 h using a Soxhlet apparatus.

Bulk densities

This was determined by the method of Narayana and Narasinga-Rao (1984). A graduated cylinder was filled to 100 ml with the sample. The sample was packed by gently tapping the cylinder on the laboratory bench. Bulk density was recorded as a ratio of weight (g) of sample to volume (ml).

Dispersibility test

Kulkarni et al. (1991) method was adopted for this determination. 10 g of each flour sample were weighed into a 100 ml measuring cylinder, and distilled water was added up to 100 ml volume. The sample was vigorously stirred and allowed to settle for 3 h; the volume of settled particles was recorded and subtracted from 100 to give a difference that is taken as percentage dispersibility.

Swelling power

Swelling power was determined by the procedure of Takashi and Seib (1988). The sample was first kept in the oven at 44°C and homogenized. 1 g of sample flour was mixed with 15 ml distilled water contained in a centrifuge tube. The slurry was stirred, the tube with the slurry was gently lowered into a water bath and held at 70°C for 15 min with slow but continuous stirring to prevent clumping with its contents. Then the tube containing the paste was centrifuged at 3000 X g for 10 min and the weight was taken after centrifuging. Swelling power was calculated as: Weight of wet mass of sediment/ Weight of dry matter in the gel

Foaming properties

Foaming capacity was determined according to Dipak and Kumar (1986). 2 g of each sample was whipped with 100 ml of distilled water at different pH ranges (2 - 10) for 5 min using a high-speed electric blender at speed 8. Volume increases on whipping was measured. Foam capacity was expressed as a percentage of the original volume of the liquid. Foam stability was expressed as a percentage of foam volume remaining in relation to initial foam volume at room temperature after 20, 40, 60, 90 and 120 min.

Statistical analysis

All the data were subjected to t-test and one way analysis of variance with the use of statistical Graph Pad- prism software (2003).

RESULTS AND DISCUSSION

Our present report is based on the premise that, a number of factors and functional properties are invariably enhanced during malting. They include diastatic power (combined effect of α- and β-amylases) of the grain, malting loss, ash composition, protein, fat, reconstitution indices, water holding capacities and foaming properties (Dewar, 1999; Onilude et al., 1999; Hassan and Arab-Aboub, 1993).

Student t-test on the diastatic power (combined effect of α- and β-amylases) confirmed that the level of amylases in barley was significantly higher than the two maize cultivars and sorghum considered in this investigation. From the diastatic power result either the SPMAT or TZEE*TZEE-W*DEMARSCUS*TZEE-W can be exploited since the level of their diastatic power was insignificantly different from each other. It has been reported that the level of α- and β-amylases in the products of cereal grains significantly affects their industrial exploitation (Palmer, 1989; Takaku, 1988). In the brewing industry, the high level of malt α- and β-amylases is a key quality parameter. In bread making, the level of amylases must be sufficient to produce saccharidase that can be absorbed and utilized by yeast, but not so high as to cause excessive starch dextrinization, which can lead to a sticky crumb and problems in processing. However elaboration of α and β-amylases during malting has been taken advantage of in the development of weaning food formulations for babies, wherein a low hot-paste viscosity and a high calorie density are desired (Takaku, 1988)

Results on malting loss also showed that barley was significantly higher than the other cereals. However, TZEE*TZEE-W*DEMARSCUS*TZEE-W and white sorghum were not significantly different while SPMAT and red sorghum have similar malting loss. Smart (1993) suggested that malting loss implies increased mobilization of the food reserves, and leaching of compounds such as oxygen and fermentative product such as little ethanol. In this study malting loss was found higher in barley followed by white sorghum, TZEE*TZEE-W*DEMARSCUS*TZEE-W and red sorghum, while the least was SPMAT. This attests to the fact why barley is the preferable choice of cereal in brewing processes (Dewar, 1999). Since the difference between TZEE*TZEE-W*DEMARSCUS*TZEE-W and white sorghum in this context is not significant, this maize variety could also be a better candidate than white sorghum especially and it might be used as an adjunct in brewing processes as commonly practiced at present (Demuyakor and Ohta, 1992; Dufour et al., 1992; Byrne et al., 1993; Owuama, 1997).

Table 1. Proximate composition and diastatic power of malted cereals.

Sample	Ash (% dry wt basis)	Protein (%)	Malting loss (% dry wt basis)	Fat (%)	α-Amylase U.per mg protein^{-1}	β-Amylase U.per mg protein^{-1}
SPMAT	2.6 ± 1.3[a]	0.4 ± 0.00[a]	15.7 ± 3.06[b]	2.8 ± 0.01[b]	106 ± 0.05[a]	123 ± 0.05[a]
TZEE*TZEE-W*DEMARSCUS*TZEE-W	3.5 ± 0.90[a]	16.5 ± 0.01[b]	8.30 ± 0.10[a]	4.6 ± 0.01[a]	98 ± 0.02[a]	125 ± 0.02[a]
Red Sorghum	2.2 ± 0.5[a]	31.2 ± 0.07[a]	16.3 ± 0.58[b]	5.9 ± 0.01[d]	142 ± 0.03[b]	158 ± 0.02[b]
White Sorghum	2.55 ± 0.75[a]	24.6 ± 0.01[b]	8.6 ± 0.12[a]	5.3 ± 0.01[d]	148 ± 0.03[b]	156 ± 0.02[b]
Barley	2.5 ± 1.2[a]	30.9 ± 0.02[a]	30.7 ± 2.31[a]	2.2 ± 0.01[c]	206 ± 0.05[c]	234 ± 0.02[c]

The results are the means of nine replicate experiments.
Varietal means with different superscript in the same column are significantly ($P < 0.05$) different from each other.

Table 2. Bulk density and some functional properties of the cereal samples.

Sample	Bulk density (g/ml)	Dispersibility (%)	Swelling power of maize (%)	Water absorption capacity (%)
SPMAT	0.551± 0.05[b]	76.2 ± 0.93[a]	0.98 ± 0.01[a]	12.0 ± 0.38[a]
TZEE*TZEE-W*DEMARSCUS*TZEE-W	0.571± 0.00[a]	72.8 ± 1.31[a]	1.02 ± 0.00[a]	78.3 ± 15.27[a]
Red Sorghum	0.618 ± 0.02[b]	80.2 ± 1.22[b]	0.98 ± 0.01[a]	11.6 ± 0.98[a]
White Sorghum	0.586 ± 0.01[b]	73.17 ± 0.071[b]	0.82 ± 0.953[a]	17.9 ± 0.2[a]
Barley	0.446 ± 0.01[a]	71.4 ± 1.36[a]	0.98 ± 0.01[a]	13.6 ± 0.42[a]

The results are the means of nine replicate experiments.
Varietal means with different superscript in the same column are significantly ($P < 0.05$) different from each other.

The malt of SPMAT and red sorghum had similar protein content which was significantly higher than the rest of the cereals under investigation. It is well documented that grain protein concentration is negatively correlated with malt extract and positively correlated with diastatic power (Arends et al., 1995; Smith, 1990; Bishop and Day, 1993). However, Molina-Cano et al. (1995) reported that grain protein concentration was significantly and negatively correlated with malt viscosity and Kolbach index [(% soluble protein/% malt protein) x 100]. For all-malt beers, protein values exceeding 12% (1.9% total nitrogen (TN)) indicate that the beer may form haze or present mash runoff problems. Based on this it can be inferred that the malt of TZEE*TZEE-W*DEMARSCUS*TZEE-W will be better compared to SPMAT. However statistical t-test (Table 1) carried out also confirmed that there was no significant difference in the ash content of all the samples investigated. This suggests that they all contain almost the same mineral content.

Lipid bodies decrease in direct proportion to the lipase content during germination due to the activation of synthesized lipase. Free fatty acids (FFAs) resulting from its hydrolysis during germination will therefore contribute significantly to the pool of FFAs available for peroxidative reactions (Palmer et al., 1989) which will result in flavour instability (rancidity) of the malt products. Since high levels of lipids limit the conservation of the flour of cereal due to hydrolytic and oxidation reactions of the lipids during storage, the cultivar TZEE*TZEE-W*DEMARSCUS*TZEE-W will also be a better candidate in this regard.

The results obtained on the functional parameters (Table 2) being considered in this investigation showed that there were generally marked variations in all the tests carried out. Tests carried out on the bulk density showed that the two maize cultivars SPMAT and TZEE*TZEE-W*DEMARSCUS*TZEE-W were significantly higher than barley but not the red and white sorghums. These high values in the two tropical plants depict that they are more bulky than the temperate plant- barley while red sorghum was the densest.

Interestingly statistical t-test carried out confirmed that there were no significant differences in water absorption capacity and swelling power in all the samples investigated. These observations suggest that they all have almost the same ability to retain same amount of water for the gelatinization process, and swell appreciably at same rate. However, dispersibility test showed that red sorghum was significantly higher than SPMAT and barley showing that sorghum flour has greater ability of reconstituting in water than other cereals. Even though there was no significant difference in dispersibility between barley and SPMAT, there seemed to be a positive correlation between the bulk density and the dispersibility. This corroborates the work of Chiek et al. (2006) on pearl Millet in Burkina faso. Hence red sorghum and SPMAT are denser and more easily dispersed than Barley.

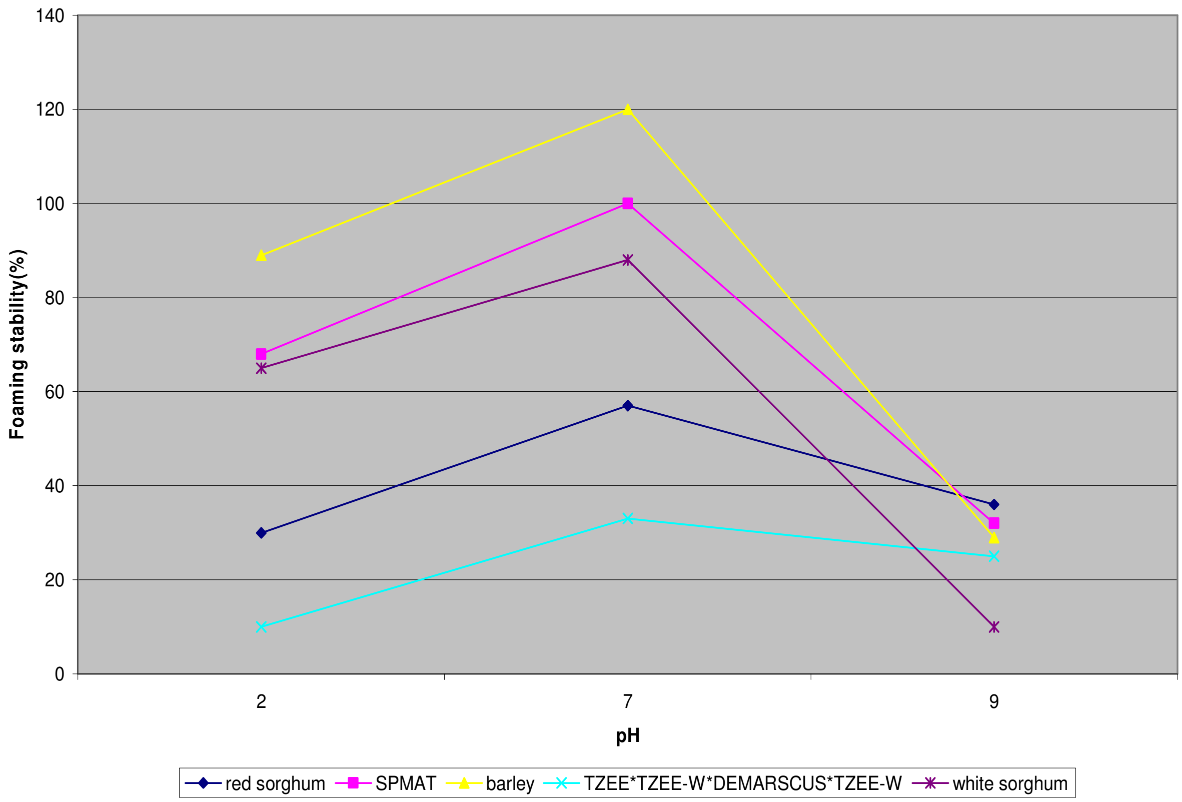

Figure 1. Foaming stability of each cereal sample relatively to pH.

All the cereals showed similar foaming behavior over same pH range. As shown in Figure 1, barley and SPMAT possess high foam stability. While TZEE*TZEE-W*DEMARSCUS*TZEE-W has the least foaming stability. Interestingly all the cereal samples showed foaming stability at neutral pH. This high stability of foam up to neutral pH region may be as result of formation of stable molecular layers in the air-water interface that imparts stability, and elasticity to the foams (Cherry and McWatters, 1981). This may account for why sorghum is popularly used for the popular opaque beer preparation like *burukutu* in *Hausa* land and *pito* as found among the *Egun* indigene in Lagos, Nigeria. In this regard SPMAT can be used for African opaque beer preparation.

Conclusion

Based on the result of the diastatic power, none of the maize cultivars in this study can be suggested to replace barley since diastatic power is the main factor that is always sought and exploited in food and allied Industry. However, based on this present study the malt of any of either maize cultivar can conveniently replace sorghum malt. Hence the malt of TZEE*TZEE-W*DEMARSCUS*TZEE-W appears to be more promising in terms of its various advantages over SPMAT.

REFERENCES

Adamson I, Anibaba TS, Osagie AU (1999). Effect of Malting on Protein Metabolism in Two Varieties of Sorghum. J. Sci. Food Agric. 74(1): 20-24.

Adewale OI, Agumanu NE, Otih-Okoronkwo FI (2006). Comparative studies on α amylase from malted maize (*Zeamays*) millet (*Eleusine coracana*) and Sorghum (*Sorghum bicolor*). Carbohydr. Polym. 66(1): 71-74

Agu RC (2002). A comparison of maize sorghum and barley as brewing adjuncts. J. Inst. Brew. 108(1): 19-22.

AOAC (1990). Methods of the Association of Official Analysis Chemists. Official methods of analysis (15th Ed.) Virginia Assoc. Off. Anal. Chem. USA. p. 1141.

Arends AM, Fox DP, Henry RJ, Marschke RJ, Symons MN (1995) Genetic and environmental variation in the diastatic power of Australian barley. J. Cereal Sci. 20: 63-70.

Awoyinka OA, Adebawo OO (2008). Influence of malting on α and β Amylases secretions in Nigerian Amylolytic maize Cultivars. Afr. J. Agric. Res. 3(1): 007-012.

Bishop LR, Day FE (1993). The effect of variety on the relation between nitrogen content and extract. J. Inst. Brew. 39: 545-551.

Byrne H, Donnelly MF, Carrol MB (1993). A comparison of some properties of barley, wheat, triticale and sorghum malts. In: Proceedings of the Fourth Scientific and Technical Convention of the Institute of Brewing. Central and Southern African Section, Somerset West, p. 13.

Chiek AT, Ouattara SA, Bayane Y, Traore SA (2006). A comparative study on nutritional and technological quality of fourteen cultivars of pearl millets (*Pennisetum glaucum* (L) Leeke] in Burkina faso. Pak. J. Nutr. 5(6): 512-521.

Demuyakor B, Ohta Y (1992). Malt characteristics of *Sorghum vulgare* varieties from Ghana. J. Sci. Food Agric. 59: 457-462.

Dewar J, Taylor JR, Berjak P (1997) Determination of improved steeping conditions for sorghum malting. J. cereal Sci. 26: 129-136.

Dewar J (1999). Influence of malting on Sorghum protein quality: A report submitted to CSIR Environmentek South Africa, pp. 1-6

Dicke WK (1953). An investigation into the injurious constituents of wheat in connection with their action on patients with coeliac disease. Acta Pediatr. 42: 223-231.

Dipak K, Kumar KD (1986). Functional properties of rapeseed protein products with varying phytic contents. J. Agric. Food Chem. 34: 775.

Dufour JP, Melotte LA, Srebrnik S (1992). Sorghum malts for the production of a lager beer. J. Am. Soc. Brew. Chem. 50: 110-119.

Egan H, kirk RS, Sawyer R (1981). Pearson's chemical analysis of food. 8th Ed.. Churchill Livingstone, Medical division of Longman group Ltd. Great Britain. pp 590-591.

Egwim EC, Oloyede BO (2006). Comparison of α amylase activity in some sprouting. Niger. Cereals Biochem. 18(1): 15-20.

Graph P (1994). Statistical Software (prism3.0) Graph Pad software Inc., 2236 Avenida de la Playa La Jolla, CA92037 USA.

Hassan AK, Arab-Abou AA (1993). Comparison of physical chemical and functional properties of Moringa peregrine and soya bean. Cereal Chem. 70(6): 619-626.

Kulkarni KD, Kulkarni DN, Ingle UM (1991). Sorghum malt-based weaning food formulations: Preparation, functional properties and nutritive value. Food Nutr. Bull. 13(4): 322-327.

Molina-Cano JL, Romera E, Aikasalo R, Pérez-Vendrell AM, Larsen J, Rubió A (2002). A reapprisal of the difference between Scandenavian and Spanish Barley: Effect of β glucan content and degradation on malt extract yield in the cv Scnvit. J. Inst. Brew. 108(2): 221-226.

Narayana K, Narasinga Rao MS (1984). Effect of partial hydrolysis on winged bean flours. J. Food Sci. 49: 944-947.

Onilude AA, Sanni AI, Ighalo MI (1999). Effect of process improvement on the physico-chemical properties of infant weaning food from fermented composite blends of cereal and soybeans. Plant Food Hum. Nutr. 54(3): 239-250.

Owuama CI (1997). Sorghum: A cereal with lager beer brewing potential . World J. Microbiol. Biotechnol. (13): 253-260.

Oyelaran OB (2002). Manufacturing response in a national system of innovation : Evidence from the brewing firms in Nigeria. United Nations University Discussion paper.

Papadopoulos G (2001). Interplay between genetics and the environment in the development of celiac disease: perspective for a healthy life. J. Clin. Invest. 108(9): 1261-1266.

Palmer GH, EtokAkpan OU, Igyor MA (1989). MIRCEN J. Appl. Microbiol. Biotechnol. 5: 265.

Shambe T, Voncir N, Gambo E (1989). Enzyme and acid hydrolysis of malted millet (*Peminsetun tyhoides*) and sorghum *(Sorghum bicolour*). J. Inst. Brew. 95: 13-16.

Smart JG, Lukes BK, Tie EC, Ford AT (1993). The relationship between wort glucan, malting conditions and malt analysis Tech. Q. master Brew. Assoc. Am. 30(3): 80-85.

Smith DB (1990). Barley seed protein and its effects on malting and brewing quality. Plant Varieties Seeds, 3: 63-80.

Takaku H (1988). Handbook of amylase and related enzyme: their sources Isolation methods properties and application, Pergamon press New York. Amylase Res. Soc. Jpn. pp. 215-217.

Takashi S, Seib PA (1988). Paste and gel properties of prime corn and wheat starches with and without native lipids. Cereal Chem. 65: 474.

Van De Kamer JH, Weijers HA (1955). Coeliac disease: Some experiments on the cause of the harmful effect of the gliadin. Acta Pediatr. 44: 465-469.