

A Comparison of Maize, Sorghum and Barley as Brewing Adjuncts

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ABSTRACT

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Sorghum and maize adjunct, at a 5 to 20% level, resulted in a decrease of extract recovery, solubilisation of nitrogen, and production of free amino nitrogen and peptide nitrogen progressively. Both sorghum and maize adjuncts released higher levels of FAN and peptide nitrogen in their extracts than barley adjuncts, but the peptide levels were higher in sorghum than maize and barley adjuncts. The solubilisation of nitrogen and hydrolysis of the soluble nitrogen were higher for high nitrogen barley adjunct than for low nitrogen barley. Although maize adjunct is used extensively in brewing, the results of this study showed that sorghum has the potential to release higher levels of peptides than maize. This difference may influence fermentation potential.

Key words: Adjuncts, barley, high nitrogen barley, low nitrogen barley, maize, malt, sorghum.

INTRODUCTION

Adjuncts are used in brewhouse operations to increase extract yield and beer stability, and possibly to reduce brewing cost. Adjuncts may be classified as “solid” such as flakes, micronised or torried grains, pelleted wheat starch, or “liquid” such as syrups. In a brewing operation, malt may be milled with the appropriate mash tun (solid) adjunct^{5,14}, to produce grists of coarse, medium and fine particle sizes. When hydrated with brewing liquor, the malt fraction can usually provide an adequate filter bed for a mixed grist wort separation. Although some advantages are assigned to the use of adjuncts in brewing, in terms of lower cost, it is also known that unmalted cereal adjuncts can dilute malt wort proteins proportionately^{4,10,11}, thereby reducing α -amino nitrogen to levels which cannot support expected growth and function of yeast during fermentation.

The infusion mashing system was developed to process well-modified malts at a relatively high mashing temperature (63–65°C)¹². Since about 70% of the α -amino nitrogen of brewer’s worts is produced during malting, inadequately low levels of α -amino nitrogen can be partly corrected in the multiple-temperature-decoction mashing system because of the relatively low mashing-in temper-

ature (< 60°C). This is difficult to correct in a single temperature infusion system of mashing, where mashing in temperatures are usually higher than 63°C. Maize and rice are popular adjuncts used in the production of lager beers and have a significant effect on α -amino nitrogen levels of brewer’s worts¹⁴. However, the economic removal of troublesome proteins and pentosans from wheat (brewing) flour has enabled wheat starch to be an economically attractive adjunct^{6,10}.

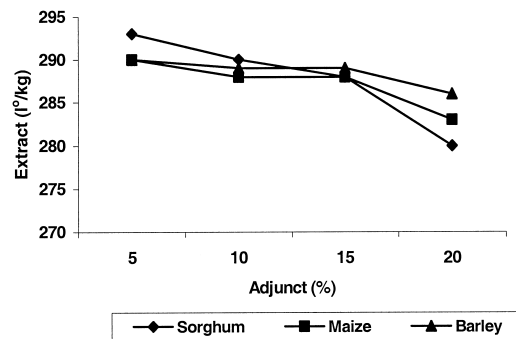


FIG. 1. Effect of level of adjunct on extract recovery.

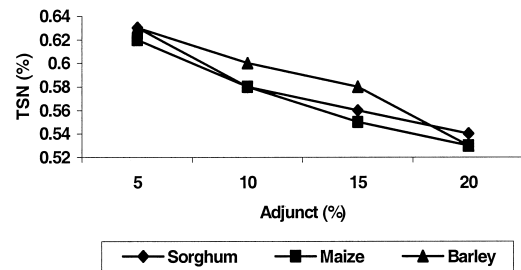


FIG. 2. Effect of level of adjunct on solubilisation of nitrogen.

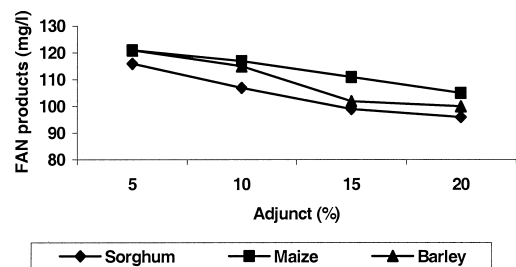


FIG. 3. Effect of level of nitrogen on FAN production (Ninhydrin assay).

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Except in Mexico and Nigeria⁵, sorghum has not been used extensively as a brewing adjunct, although its potential as a brewing adjunct has been promoted. The sorghum grists offer some advantages in the brewhouse, such as short boiling time, fast run-off, more usable extract and highly nutritious worts⁷. A study on the effect of sorghum in comparison with other cereal adjuncts on wort properties, especially in relation to amino acid (FAN) and peptide content, is now reported.

MATERIALS AND METHODS

Delibes barley and malt were obtained from the United Distillers Limited, Edinburgh, Scotland. Sorghum was obtained from Nigeria and maize grit was obtained from the University's microbrewery store.

Mashing of Delibes malt

Infusion mashing at 65°C. Barley malt flour (50 g, Buhler Miag mill, setting 2), from Delibes barley was mixed with 360 mL of distilled water, equilibrated at 65°C. Mashing was carried out in the BRF mashing bath (Crisp Malting Ltd, Great Ryburgh, UK) at 65°C for 1h.

Mashing of malt with the different adjuncts. Sorghum grist, maize grits, Delibes, low (1.7%) and higher (1.9%) nitrogen type grists, were mashed with malt. Malt flour and adjunct were mixed in a proportion such that Xg malt + Yg of adjunct gave a 50 g sample. Adjunct, Yg, (5-20% or 2.5-10 g), contained in a stainless mashing beaker, was separately mixed with 30 mL of distilled water, cooked for 3 or 5 min in a boiling water bath to gelatinise the starch and then cooled to 20°C. During the cooking process of the adjunct, no malt or enzymes were added. After cooling, the cooked adjunct was added to Xg malt contained in the mashing vessel, after which 330 mL of distilled water was added, and the sample mashed at 65°C for 1 h. Worts were collected as recommended⁹.

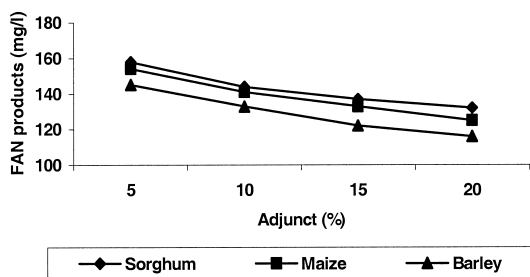


FIG. 4. Effect of level of nitrogen on FAN production (TNBS assay).

Wort analyses

Extract determination. Hot water extract of the different mashes was determined as reported elsewhere¹.

Total soluble nitrogen. This was determined by the Kjeldhal method².

α-Amino nitrogen and peptides. Wort α-amino nitrogen was determined by two methods – the Ninhydrin⁹ and the 2,4,6-trinitrobenzene sulphonic acid method⁶. Experimental errors not exceeding 5% were tolerated.

RESULTS AND DISCUSSION

Results in Figure 1 show that at lower adjunct level sorghum produced higher extracts than maize. This is also seen in Table I where the extract yield of all-malt mash was compared to those of 5% sorghum and maize adjuncts. It is important to note from Table I that the low adjunct level of sorghum produced similar extract and soluble nitrogen to those found in all-malt worts. However, it appeared that peptide levels of sorghum were higher than those of the all-malt control; and peptides of maize and especially sorghum were higher than those of the barley adjuncts (Table I). The extract recovery for maize was higher than that of sorghum at higher adjunct levels (Fig. 1). In contrast, at higher adjunct levels, extract

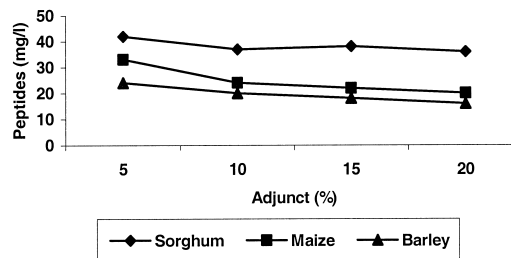


FIG. 5. Effect of level of adjuncts on peptide release pattern.

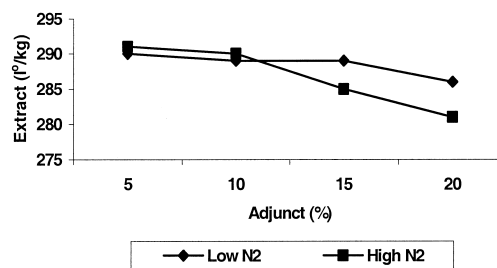


FIG. 6. Effect of level of adjunct of low or high nitrogen barley on extract yield.

TABLE I. Comparison of all-malt wort with 5% and 20% cereal adjunct wort properties.

Variables	All-malt	Sorghum grist		Maize grits		Delibes, L N ¹		Delibes, H N ²	
		5%	20%	5%	20%	5%	20%	5%	20%
Extract, l/kg	292	293	280	290	283	290	286	291	281
TSN, %	0.64	0.63	0.54	0.62	0.53	0.63	0.53	0.62	0.57
FAN, mg/litre	126	116	96	121	105	121	100	123	98
Ninhydrin FAN, mg/litre	167	161	132	154	125	145	116	143	121
TNBS Peptides, mg/litre	41	45	36	33	20	24	16	20	23

¹ LN = Low Nitrogen .

² HN = High Nitrogen.

yield was highest for barley adjuncts when compared with sorghum and maize adjuncts (Fig. 1 and Table I). Although the reason for this observation is not quite clear, the higher yield of extract associated with barley adjunct might be linked to the mashing conditions because the starch extract yield potential of sorghum and maize are greater than those of barley¹².

With regard to solubilisation of nitrogen, this parameter decreased when higher levels of sorghum and maize adjuncts were used in the mashing process (Fig. 2 and Table I). Results (Fig. 2) suggest that nitrogen solubilisation of sorghum adjunct was marginally but consistently greater than that of maize adjunct. When barley was the cereal adjunct more soluble nitrogen was found in the worts (Fig. 2). Although solubilisation of nitrogen was marginally higher in sorghum than in maize mashes (Fig. 2), hydrolysis of the soluble nitrogen to produce FAN (Ninhydrin assay) was higher in maize mashes than in sorghum mashes (Fig. 3 and Table I). FAN production in barley mashes, under this assay condition, was higher than in sorghum mashes (Fig. 3). The cooked proteins of unmalted maize may have been more susceptible to hydrolysis by carboxypeptidases than the corresponding proteins of cooked barley and sorghum adjuncts.

In contrast, when the FAN products were assayed by the TNBS method (Fig. 4), rather than by the Ninhydrin method (Fig. 3), it can be seen that sorghum produced the highest FAN products in the TNBS assay (Fig. 4). This caused sorghum to release more peptides in sorghum worts than in maize worts or barley worts (Fig. 5 and Table I). The TNBS assay measures both FAN and peptide nitrogen¹. Barley adjuncts produced worts containing lowest FAN products in the TNBS assay (Fig. 4), and hence contained the lowest levels of peptides (Fig. 5).

These results suggest that cooked sorghum proteins are more susceptible than the corresponding protein of maize and barley to proteolytic activity that releases peptides in worts during mashing.

It has been reported⁷ that sorghum adjunct worts have higher nutritional values than those of maize adjunct worts. Since yeast can metabolise peptides during fermentation^{8,13}, and since sorghum worts had higher levels of peptides than maize or barley worts, one of the beneficial nutritional qualities, reported by Haln⁷ for sorghum worts, may have been higher levels of peptides. Barleys such as Chariot can produce lower levels of soluble nitrogen and α -amino nitrogen than other barley varieties, but can support similar levels of yeast performance. It is probable that the peptides of barleys such as Chariot may play a more important part in yeast metabolism during fermentation than previously considered³.

Comparison of low and high nitrogen Delibes barley for use as adjunct showed that at lower adjunct levels, the higher nitrogen barley produced more extract than the low nitrogen barley. But when the adjunct level was increased, the low nitrogen barley developed more extract than the high nitrogen barley (Fig. 6). Although the reason for this observation was not investigated in this study, evidence exists to show that higher nitrogen barleys produce more soluble nitrogen in their extract, and lower nitrogen barleys produce more carbohydrates in their extract (Agu and Palmer, unpublished data). This assertion is supported by Fig. 7, where greater solubilisation of nitrogen is seen with the high nitrogen barley than with the low nitrogen barley at increased adjunct levels. It is important to note that while both the low and high nitrogen barleys produced different levels of soluble nitrogen, the production of α -amino nitrogen was similar for both types of Delibes

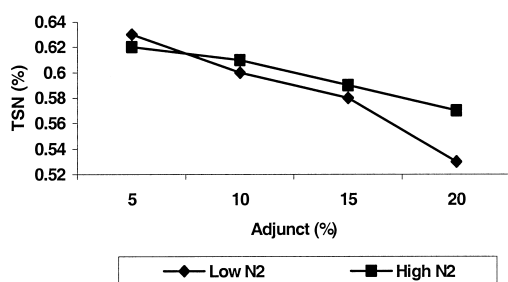


FIG. 7. Effect of level of adjunct of low or high nitrogen barley on solubilisation of nitrogen.

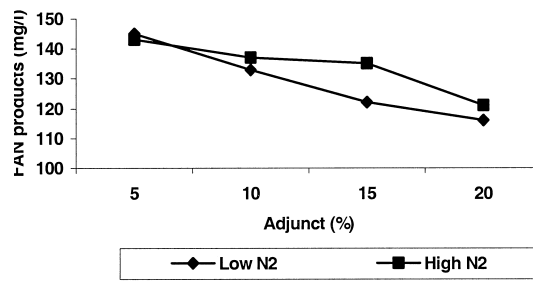


FIG. 9. Effect of level of adjunct of low or high nitrogen barley on FAN production (TNBS assay).

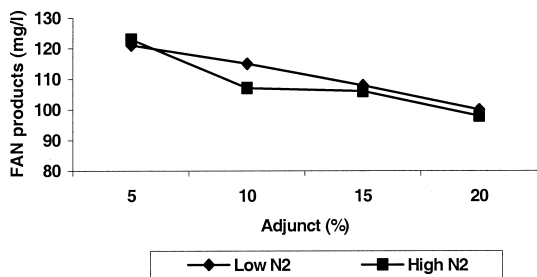


FIG. 8. Effect of level of adjunct of low or high nitrogen barley on FAN production (Ninhydrin assay).

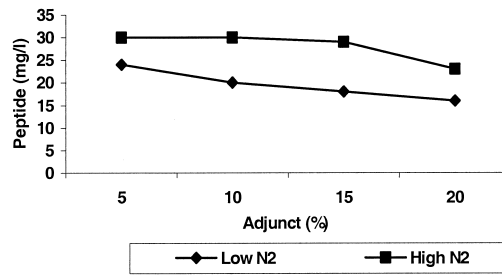


FIG. 10. Effect of level of adjunct of low or high nitrogen barley on peptide release pattern.

barley in the Ninhydrin assay (Fig. 8). In contrast, when the FAN production was assayed using the TNBS method, the high nitrogen barley gave a higher value of FAN products (Fig. 9), and the peptide levels were higher in the worts produced from the high nitrogen barley (Fig. 10).

CONCLUSION

A comparison of different adjuncts showed that at the 5% level of adjunct, worts of similar properties, to those of all-malt wort, were produced. An increase in the level of the adjuncts from 5% to 20% caused a decrease of all soluble proteins analysed in the wort. At both the low and high adjunct levels, sorghum produced the highest level of peptides. Sorghum however, produced a lower level of FAN than maize and barley. Low and high nitrogen barley adjuncts produced soluble nitrogen at different levels, but hydrolysis of the soluble nitrogen to yield FAN products occurred at similar levels. The high nitrogen barley adjunct was associated with the production of more peptides than the low nitrogen barley adjunct. The higher peptide levels found in sorghum worts, when compared to those found in maize or barley worts, may be metabolised faster than the FAN level during the early stages of yeast fermentation.

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