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RESEARCH ARTICLE

Mashing studies using Tiger Nut (*Cyperus esculentus*) flour as adjunct in brewing

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ABSTRACT

Brewing industry worldwide is constantly looking for ways to reduce production costs and improve product quality. This has been done over the years using cereal extracts known as adjuncts. An increasing world population requires increased production of grains for consumption which necessitates research into non-grain sources as adjuncts for brewing. Tiger nut (*Cyperus esculentus*) flours were utilized in this work to investigate its suitability for use as brewing adjunct in conjunction with malted barley. Proximate analysis and mashing process were carried out on the samples and the resulting wort analysed. Tiger nut flour was defatted using Soxhlet extraction method to reduce the fat content to a level tolerable for brewing, 18.74% for the normal tiger nut (NTN) flour and 1.30% for the defatted tiger nut (DTN) flour which compared with the barley malt with lipid content of 2.58%. The normal and defatted tiger nut flours had total carbohydrate content of 50.61 and 55.83% respectively while barley malt was 79.44%. The barley malt also had a diastatic power of 119 °L. Various worts were obtained by an infusion mashing system for the all-barley malt mash and double mashing system for the malt and adjunct mashes (NTN and DTN flours) using the gelatinization temperature of 66 °C for the tiger nuts. Tiger nut flours were mashed with barley malt in combinations of 50/50 and 30/70 to produce wort. All the worts obtained tested negative for starch using the Iodine test. Extract values for the 70/30 and 50/50 barley malt-NTN combinations were 13.05 °P and 13.8 °P respectively. The 70/30 barley malt-DTN and 50/50 DTN combinations also gave extract values of 11.60 °P and 12.94 °P respectively. The wort from the 50/50 DTN combination compared most favorably to the wort obtained from the all-barley-malt mash. This indicates that there is potential for the use of tiger nut flours as adjunct in brewing although there is a need for further studies on more efficient methods of reducing lipid content.

Key Words: Tiger nut (*Cyperus esculentus*) flour, beer, brewing, adjuncts, fermentation

1. INTRODUCTION

Beer can be described as an alcoholic beverage produced from the yeast fermentation of a sugary extract from cereals. Beer production encompasses five main stages which includes malting; mashing; wort boiling with hops; fermentation; and post-fermentation treatments [1]. All over the world, brewers are

consistently looking for cheaper sources of extract to reduce cost of production and improve beer quality. In tropical countries, barley has to be imported from other temperate countries and this involves expenditure of scarce foreign exchange. Economic situations in developing countries have necessitated research on alternative brewing raw materials as barley cannot grow in most of these countries [2].

Adjuncts are unmalted grains such as maize, rice, rye, oat, barley and wheat which are used in beer brewing to supplement the main mash ingredient (malted cereal), often with the intention of cutting costs, but sometimes to create an additional feature, such as better foam retention, flavours or nutritional value or additives [3]. For many years adjuncts such as corn, rice, unmalted barley, wheat starch and sorghum have been used by the brewing industry to provide fermentable carbohydrates for the yeast [4]. Hitherto, sorghum has been the grain of choice for use in Nigeria as adjuncts in lager beer brewing [5]. Other grains include wheat, maize and rye. The increasing world population necessitates high production of grains to cater for the food needs of the masses, leaving little available for use as adjuncts. This looming problem requires more research for non-grain sources of extract for brewing so as to relieve pressure on cereals and prevent food scarcity. The search for lesser known and underutilized crops, many of which are potentially valuable as human and animal foods has been intensified to maintain a balance between population growth and agricultural productivity, particularly in the tropical and sub-tropical areas in the world [6]. Tiger nuts are edible, sweet, nutty, flavoured tubers which contain proteins, carbohydrates, and lots of oil and fiber [7]. Tiger nut tubers have been reported to have high starch content, as high as almost double the starch content of sweet potato [8]. Mashing, a key step in beer production, involves the production of fermentable carbohydrates from the breakdown of starch. With its high starch content, tiger nut could serve as an alternative and cheaper source of extract for the brewing industry.

2. METHOD AND MATERIAL

2.1. Preparation of Barley Malt sample

Malted barley grains were obtained from International Breweries Plc, Onitsha. The grains were sorted by hand to remove damaged and broken kernels then milled into grist using Buhler-Miag milling machine.

2.2. Preparation of Tiger nut flour samples

Dried tiger nuts were obtained from a local market in Onitsha, Anambra state, Nigeria and sorted to remove foreign particles and damaged seeds. They were further dried using hot air oven at 50 °C for 24hours to reduce moisture content and then milled using Buhler Miag milling machine to obtain the normal tiger nut (NTN) flour. The normal tiger nut flour (NTN) was defatted using the Soxhlet extraction method with n-hexane as solvent to obtain defatted tiger nut (DTN) flour.

2.3. Proximate Analysis

Chemical compositions of the barley malt and tiger nut flour samples were analyzed as

described by the AOAC (2016) [9]. Crude protein was measured using the macro-Kjeldahl method, crude fat by the Soxhlet extraction method, crude fibre by the gravimetric method and ash content Moisture content was determined using the method recommended by the ASBC (2009) [10]. Total carbohydrate was determined by difference of 100% with other components as described by McCleary *et al*. (2019) [11].

2.4. Mashing process

This process was as adapted from Archibong *et al*. (2015) [12]. This was done using different ratios of tiger nut flour to barley malt; 50/50 and 30/70 with a grist to water ratio of 1:5. The tiger nut flour was mashed with distilled water into an adapted cereal cooker in a water bath at 50 °C and rested for 30 mins with intermittent stirring. The mash was then heated up 70 °C (for tiger nut) for gelatinization. One milligram (1 mg) of Cerezyme (a commercial enzyme) was added to the adjunct mash. Barley malt was mashed into a separate vessel at 50 °C and rested for 30 mins. The mash was then heated to 60 °C and also rested for 30 mins. At this point, the adjunct mash was transferred to the main mash and the temperature held at 67 °C. The mash was rested at this temperature for 30 mins before being heated to 72 °C and rested for 10 mins also with continuous stirring for even mash thickness and temperature. A saccharification test was carried out at this point which was negative showing total conversion of starch present in the mash. The mash was heated to 78 °C to denature all enzymes and terminate the mashing process, known as mashing off. The mash was filtered using a Whatman No.1 filter paper and a funnel to separate the clear wort from the spent grains.

Table 1. Proximate Analysis of Barley Malt and Tiger Nut Flours

Parameters (%)	Barley Malt	Tiger Nut	
		Normal	Defatted
Crude protein	9.19	11.50	13.44
Total lipid	2.58	18.74	1.30
Ash	2.05	3.15	4.19
Moisture content	2.44	9.50	12.10
Crude fibre	4.30	6.50	13.14
Total carbohydrate	79.44	50.61	55.83

Table 2. Malting Parameters of Barley Malt

Parameters	Barley Malt
Free Amino Nitrogen (mg/l)	187
Diastatic Power (°L)	119
Total Soluble Nitrogen (TSN) (%)	0.748
Total Nitrogen (TN) (% N)	1.767
Kohlbach Index (TSN/TN)	42.2
Extract (% dry solids)	80.1
Wort β-glucan (mg/l)	138

3. RESULTS AND DISCUSSION

The proximate composition of all the samples; barley malt, sorghum, normal tiger nut and defatted tiger nut flours were presented in Table 1. Barley malt had the highest amount of total carbohydrate while the NTN flour had the lowest (Table 1). Aremu *et al.* (2015) reported slightly higher carbohydrate levels for dried tiger nuts at 65.66% [13]. Kuner *et al.* (2002) reported that tiger nut tubers contain almost twice the quantity of starch as sweet potato tubers [8]. The defatted tiger nut (DTN) flour had the highest protein content while barley malt had the least (Table 1). Tiger nut has been found to contain relatively high levels of protein [14]. The proximate analyses of all the samples showed that tiger nut flours had higher crude fibre content than barley malt which would be useful in wort filtration after mashing (Table 1). The normal tiger nut (NTN) flour also had the highest lipid content which would serve as a limitation to its use in brewing due to filtration issues, colloidal instability and subsequent haze formation in beer. This is

Table 3. Wort Analysis for Barley Malt Mash

Parameters	**Results**
Specific Gravity	1.05436
Extract yield (^oP)	13.88
Wort pH	5.51
Wort Colour (EBC)	7.9
Wort Viscosity (cP/cS)	1.60, 1.52
Iodine Test	Negative
Free Amino Nitrogen (FAN) (mg/l)	220.2
Total Reducing Sugars (mg/ml)	115.4±8.7
Total Soluble Nitrogen (TSN) (%)	3.651
Fat Content (%)	0.396
Total Fermentable Sugars (mg/ml)	
Glucose	5.36
Maltose	72.63
Maltotriose	17.6
Maltotetraose	12.2

Table 4. Wort Analysis of 50/50 and 30/70 NTN Flour and Barley Malt Mash

Parameters	**30% NTN**	**50% NTN**
Specific Gravity	1.05547	1.06311
Extract yield (^oP)	13.05	13.81
Wort pH	5.71	5.65
Wort Colour (EBC)	11.2	12.7
Wort Viscosity (cP/cS)	1.57, 1.49	1.65, 1.55
Iodine Test	Negative	Negative
Free Amino Nitrogen (FAN) (mg/l)	207.18	225.65
Reducing Sugars (mg/ml)	118.2±3.5	109.4±2.1
Total Soluble Nitrogen (TSN) (%)	3.015	3.822
Fat Content (%)	1.711	2.052
Total Fermentable Sugars (mg/ml)		
Glucose	3.85	4.55
Maltose	63.81	60.1
Maltotriose	25.51	22.15
Maltotetraose	-	-

because tiger nut tubers are known to be rich in lipids and oils such as oleic, linoleic and linolenic acids [15]. This limitation was removed by defatting the tiger nut flour resulting in the defatted tiger nut (DTN) flour which had a very low fat content and slightly increased carbohydrate content (Table 1).

The diastatic power of the malt was observed to be 119 °L (Table 2) which is a measure of the amylolytic activity present in the malt [16]. The extract content was observed as 80.10% (Table 2) while the free amino content (FAN) was 187mg/l which indicates the amount of amino acids available to support yeast activities during fermentation. These values are well within the acceptable specifications of the European Brewing Convention (EBC) for lager malt [17].

The wort produced entirely from barley malt had extract value of 13.88 °P and pH of 5.51 (Table 3). The fat content of the all-barley malt mash was <0.5% with free amino nitrogen (FAN) content of 220.20mg/l. There was also presence of various fermentable sugars such as glucose, maltose, maltotriose and maltotetraose with maltose being in highest concentration at 72.63mg/ml (Table 3).

Tables 4 and 5 presented the results of the wort analysis after mashing with normal tiger nut (NTN) flour and defatted tiger nut (DTN) flour respectively. Shaker *et al.* (2009) also revealed that tiger nuts have high sodium, calcium, phosphorus contents and are low in magnesium, manganese, iron, zinc and copper content [18]. The high content of calcium found in tiger nut tubers is adequate for bone and teeth development in humans. Thus, its use as a brewing adjunct improves nutritional content of beer. The worts produced from a combination of barley malt and tiger nut flours had a higher colour than that produced from a combination of barley malt and sorghum (Tables 4 and 5). This is due to the natural brown colour of the dried tiger nut tubers. There was also observed absence of maltotetraose in all the worts produced with tiger nut flour adjunct.

The total soluble nitrogen (TSN) and free amino

Table 5. Wort Analysis of 50/50 and 30/70 DTN Flour and Barley Malt Mash

Parameters	**30% DTN**	**50% DTN**
Specific Gravity	1.04663	1.05228
Extract yield (°P)	11.60	12.94
Wort pH	5.85	5.70
Wort Colour (EBC)	10.20	11.90
Wort Viscosity (cP/cS)	1.43, 1.37	1.35, 1.27
Iodine Test	Negative	Negative
Free Amino Nitrogen (FAN) (mg/l)	255.55	268.58
Reducing Sugars (mg/ml)	105.5±6.5	99.4±5.1
Total Soluble Nitrogen (TSN) (%)	3.319	4.165
Fat Content (%)	0.228	0.455
Total Fermentable Sugars (mg/ml)		
Glucose	3.70	3.25
Maltose	60.15	57.18
Maltotriose	22.15	20.75
Maltotetraose	-	-

nitrogen (FAN) values were found to be higher in the worts with tiger nut flour due to the higher protein content in tiger nut. FAN levels of 200-250mg/l are regarded as optimum for standard gravity brewery fermentations [19]. Thus, the worts obtained using tiger nut flours as adjunct were suitable for fermentation.

The wort obtained from mashing with NTN flour had higher extract values than those obtained from using DTN flour but wort viscosities were higher in the former due to the higher lipid contents. This could hinder fermentation by limiting yeast growth [20]. The wort produced from 50% barley malt and 50% DTN flour compared most favorably as the fat content was most similar (<0.5%) to that of the wort from barley malt (Table 5). All the worts tested negative for the presence of starch via the iodine test which indicated complete saccharification of the mash.

4. CONCLUSION AND RECOMMENDATIONS

This research has shown that there is great potential in the use of tiger nut flour as brewing adjunct. Wort obtained using defatted tiger nut (DTN) flour was similar in quality analytically to that obtained from an all-barley-malt mash.

There is need for more in-depth research to further analyze and evaluate the properties and effects of tiger nut as an adjunct. This novel line of research, if diligently pursued will reduce dependence on cereal adjuncts making them more available to feed the increasing global population.

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NA

6. CONFLICT OF INTEREST

The authors have declared that there is no conflict of interest.

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8. REFERENCES

1. Bai, J., Huang, J., Rozelle, S., Boswell, M. (2012) Beer battles in China: the struggle over the world's largest beer market. In: The Economics of Beer. *Oxford Scholarship Online*, **15**:267–286
2. Igyor, M. A. (2005). Effects of Processing Methods on Sorghum Wort Filtration. *Nigerian Food Journal*, **23:** 218-224
3. Figueroa, J. D. C., Martínez, B. F., and Ríos, E. (1995).Effect of sorghum endosperm type on the quality of adjuncts for the brewing industry. *Journal of American Society of Brewing Chemists*, **53*(1)***: 5–9.
4. Pei, S. C., Li, Y. H., Zhang, Y., Cai, L., and Lee, W. J. (2010). Detection of aflatoxin B1 in corn, rice, and barley by ELISA, using a heavy-chain igG 2b isotype monoclonal antibody. *Journal of American Society of Brewing Chemists*, **68*(1)***: 10–14
5. Aisien, A. O. and Muts, G. C. J. (1987). Micro-scale malting and brewing studies of some sorghum varieties. *Journal of the Institute of Brewing*, **93**:328-331
6. Adejuyitan, J.A. (2011). Tigernut Processing: Its Food Uses and Health Benefits. *American Journal of Food Technology*, **6*(3)***:197-201
7. FAO (1988).Traditional Food Plants: Food and Nutrition Paper In Fermented Fruits

and Vegetables: A Global Perspective; Edited by Battcock, M. and Azam- Ali, S. *FAO Agricultural Services Bulletin*, **134*(42)***: 239-242. Rome.

8. Kuner, Y.C., Ercan, R. and Karababa, E. (2002). Chemical properties of chufa (Cyperus esculentus L.) tubers found in the Cukurova region of Turkey. *Journal of Food Science and Agriculture*, **82**: 625-631.
9. AOAC (2016).Official Methods of Analysis of the Association of Analytical Chemists, 20th Edition. Washington D.C.
10. ASBC (2009) American Society of Brewing Chemists Methods of Analysis, online. Approved (1958), Reviewed (2009). *Proceedings of the American Society of Brewing Chemists*.**2**:11-14.
11. McCleary, B., McLoughlin, C., Charmier, L. M. J. and McGeough, P. (2019).Measurement of Available Carbohydrates, Digestible, and Resistant Starch in Food Ingredients and Products. *Cereal Chemistry*, **97*(8)***:1-24.
12. Archibong, E.J., Ezemba, C. C., Chukwujama, I. C and Archibong, U. E. (2015). Production of Wine from Mixed Fruits: Pineapple (Annas comosus) and (Citrus simensis) Using Yeast Isolated from Palm Wine. *World Journal of Pharmacy and Pharmaceutical Sciences*, **4**:126-136.
13. Aremu, M. O., Bamidele, T. O., Agere, H., Ibrahim, H., and Aremu, S. O. (2015).Proximate Composition and Amino Acid Profile of Raw and Cooked Black Variety of Tiger Nut (Cyperus esculentus L.) Grown in North-East Nigeria. Journal of Biology, *Agriculture and Healthcare*. **5*(7)***: 213-221.
14. TTSL (2005). Tiger nut and Health. Tiger nuts Traders, S.L. Export. Retrieved from http://www.tigernut.com.
15. Moore, M. (2004) Documents Prepared for Bottlegreen for the Product Tiger White: Retrieved from: www.tigerwhitedrinks.com/ Pp 1-22.
16. Dornbusch, H. (2012). Wheat malt. In: The Oxford Companion to Beer, Oxford University Press, New York, pp. 839
17. O'rourke, T. (2002). Malt Specifications and Brewing Performance. *The Brewer International*, **2*(10)***:27-30
18. Shaker, M. A., Ahmed, M. G., Amany M. B. and Shereen L. N. (2009). Chufa Tubers (Cyperus esculentus L.): As a New Source of Food. *World Applied Sciences Journal*,**7*(2)***: 151-156
19. Hill, A. E. and Stewart, G. G. (2019). Free Amino Nitrogen in Brewing. *Fermentation*, **5*(1)***:22
20. Kunze, W. and Manger, H.-J. (2004). Technology Brewing and Malting. Berlin: VLB Berlin